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DEPARTMENT OF DEFENSE
STANDARD PRACTICE

PROPULSION SYSTEM
INTEGRITY PROGRAM (PSIP)

AMSC N/A

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DISTRIBUTION STATEMENT A. Approved for public release: distribution is unlimited.

FOREWORD

1. This standard is approved for use by all Departments and Agencies of the Department of Defense.

2. The Department of Defense (DoD) is committed to ensuring a strong systems engineering approach in acquisition programs. This standard covers the procedures to be used to ensure propulsion system integrity during the Engineering and Manufacturing Development (EMD) phase of a program and sustainment. These procedures describe the tasks necessary to attain knowledge that will allow systems engineering for the propulsion system to be accomplished in a cost-effective manner. (Statutes applicable to the Systems Development and Demonstration Phase shall be applicable to the EMD phase as described in DoDI 5000.02).

3. Comments, suggestions, or questions on this document should be addressed to AFLCMC/ENRS, BLDG 28 RM 118, 2145 MONAHAN WAY, WPAFB, OH 45433-7017 or e-mailed to Engineering.Standards@us.af.mil. Since contact information can change, you may want to verify the currency of this address information using the ASSIST Online database at https://assist.dla.mil.

SUMMARY OF CHANGE 1 MODIFICATIONS

1. Changed the Uniform Resource Locator (URL) for the Acquisition Streamlining and Standardization Information System (ASSIST) database throughout the document

2. Updated source information for references in Sections 2 of the document

3. Updated acronym list

4. Updated Appendix A for Technical Review criteria.

5. Updated Review Activities in Concluding Material

6. Modifications have been made to MIL-STD-3024, as follow, to:

   a. Address airworthiness issues raised by recent developmental programs,

   b. Resolve all Integrity Program disconnects from the former MIL-HDBK-1783B,

   c. Improve Life-cycle management of propulsion systems, and

   d. More fully implement the Systems Engineering aspects of DoDI 5000.02.

PARAGRAPH	MODIFICATION
Foreword	Changed
2.2	Changed
2.3	Changed
3.1	Changed
3.2.4	Inserted
4.2	Changed
4.3.1	Changed
4.3.4	Changed
4.3.5	Changed
4.4.1.2	Changed
4.4.2.3	Changed
5.1.1	Changed
5.1.1.1	Changed
5.1.1.2	Changed
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5.1.1.3.5	Changed
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Concluding Material	Changed .

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FIGURE

APPENDIX A

TABLES

1. SCOPE.

1.1 Purpose. This standard describes the Propulsion System Integrity Program (PSIP) and defines the requirements necessary to achieve integrity in propulsion systems while the cost of ownership is minimized; and cost and schedule risks managed through a series of disciplined, time phased tasks. This standard details programmatic tasks for the development, acquisition, and sustainment of propulsion systems to ensure their integrity while affordability of these United States Air Force (USAF) systems is maintained throughout their period of use.

1.2 Application. This standard provides information to develop a Propulsion System Integrity Program. The standard applies to a particular propulsion program and air vehicle system, as follows:

1.2.1 Type of air vehicle. This standard is directly applicable to air vehicles which have a propulsion system based on or powered by a gas turbine engine.

1.2.2 Type of propulsion system. This standard applies to gas turbine propulsion systems. The term "Propulsion System" in this document refers to an engine and engine accessories. Inlets, nacelles, pylons, engine bay, and ventilation components are not intended to be included in this document. Exhaust nozzles are intended to be included in this document, even those designed and manufactured by an airframe manufacturer.

1.2.3 Type of program. This standard is applicable to new propulsion systems, to propulsion systems procured by the USAF but developed under the auspices of other government agencies or departments (such as the Federal Aviation Administration or United States Navy), and propulsion systems modified or directed to new missions.

1.2.3.1 Program impact on tailoring. It is expected this standard will be tailored to fit the needs of a given program. Specific tailoring guidance is given in 6.3. Procurement of off-the-shelf, new or used propulsion systems for military use presents different challenges than procurement of propulsion systems developed under the auspices of the military services. The concepts and intent of this document will apply to these types of systems, but may require significant tailoring.

1.3 Functional scope. This document details the PSIP requirements for the functional areas of Structures, Performance and Operability, and Controls and Subsystems. As will be described in section 4, development of the PSIP Master Plan is a significant requirement to achieve system integrity. The Master Plan is expected to be comprehensive, and include activities needed to attain integrity in other functional areas, such as Manufacturing, Safety, Reliability and Maintainability, etc. Detailed PSIP requirements for these functional areas are not included in this document due to the availability of other government guides, handbooks, and standards.

1.4 Document layout. This document follows the prescribed format for military standards, which reserves section 4 for General Requirements and section 5 for Detailed Requirements. Within this construct this document covers three functional areas with five PSIP task categories. To achieve this, it was decided all Task I requirements were universally applicable to the three functional areas and would be included in section 4, General Requirements. Section 5, Detailed Requirements, contains three primary subsections, each identifying the Task II – V requirements for each functional area. Although it could be argued that Task V applies to all functional areas, it was considered unique for each for the initial release of this document. Appendix A contains tables which list guidance for Task completion criteria for the various program milestones. This guidance is to be used to develop criteria to move to the next program milestone as described in 4.4.2.2. Microsoft Word® and Adobe Acrobat® versions of this document contain hyperlinks which are identifiable by blue-font characters. Once selected, a hyperlink will take the user to a referenced paragraph, table, figure, and Website. The simplest way to return to the place of origin within a Microsoft Word® document is to click the "back arrow" on the "Web" toolbar. This toolbar can be displayed by selecting "View" and "Toolbars" on the menu bar, and then selecting the "Web" option. This same method can be employed in Adobe Acrobat® versions of a document: select

"View" and "Toolbars" on the menu bar, and then select "Navigation." The "back arrow" and "forward arrow" allow the user to return to the place of origin after a hyperlink has been selected.

2. APPLICABLE DOCUMENTS.

2.1 General. The documents listed in this section are specified in sections 3, 4, or 5 of this standard. This section does not include documents cited in other sections of this standard or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements of documents cited in sections 3, 4, or 5 of this standard, whether or not they are listed.

2.2 Government documents.

2.2.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

DEPARTMENT OF DEFENSE

Specifications

JSSG-2007 Engines, Aircraft, Turbine

Handbooks

MIL-HDBK-1783 Engine Structural Integrity Program (ENSIP)

(Copies of these documents are available online at http://quicksearch.dla.mil/ or from the Standardization Document Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094; [215] 697-2179.)

2.2.2 Other Government documents, drawings, and publications. The following other Government documents, drawings, and publications form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

UNITED STATES AIR FORCE INSTRUCTIONS

AFMCI21-102 Analytical Condition Inspection (ACI) Programs

AFMCI21-103 Reliability-Centered Maintenance (RCM) Programs

(Copies of these documents are available online at www.e-publishing.af.mil.)

2.3 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

PROPULSION CENTER OF EXCELLENCE (PCoE) BEST PRACTICES

PCOE BP-01-11 Propulsion System High Cycle Fatigue Test Protocol

(Copies of this document are available online to qualified users at the PCoE site on the Air Force Portal, https://cs.eis.afmc.af.mil/sites/Propulsion/PCOE/default.aspx.)

RADIO TECHNICAL COMMISSION FOR AERONAUTICS (RTCA), INC.

RTCA DO-178 Software Considerations in Airborne Systems and Equipment Certification

(Copies of this document are available online at www.rtca.org.)

Shock and Vibration Handbook, Cyril M. Harris, 4th edition, McGraw Hill, New York NY, 1995.

(Copies of this document are available to DoD users through http://www.afit.edu/library/ and all users at various public library sites.)

2.4 Order of precedence. Unless otherwise noted herein or in the contract, in the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. DEFINITIONS.

3.1 Acronyms.

ACI	Analytical Condition Inspection
AMT	Accelerated Mission Test
ASIP	Aircraft Structural Integrity Program
ASMET	Accelerated Simulated Mission Endurance Test
ATP	Acceptance Test Procedure
AVIP	Avionics Integrity Program
CIP	Component Improvement Program
CMC	Ceramic Matrix Composites
COTS	Commercial Off-The-Shelf
CSC	Computer Software Configuration
CSCI	Computer Software Configuration Item
DTR	Design Target Risk
ECS	Environmental Control System
EFH	Engine Flying Hour
ELMP	Engine Life Management Plan
EMD	Engineering and Manufacturing Development
ESW	Engineering Standard Work
FDA	Failure Detection and Accommodation
FEM	Finite Element Model
FFR	Full Flight Release
FMECA	Failure Modes Effects and Criticality Analysis
HCF	High Cycle Fatigue
ICD	Interface Control Document
IFPC	Integrated Flight/Propulsion Controls
IFR	Initial Flight Release
IMP	Integrated Master Plan
IMS	Integrated Master Schedule
IR	Infrared
ISR	Initial Service Release
K_{1C}	Stress intensity factor
LCF	Low Cycle Fatigue
LDTO	Lead Development Test Organization
LPB	Low Plasticity Burnishing
LSP	Laser Shock Peening
MAC	Modal Assurance Criteria
MECSIP	Mechanical Equipment and Subsystems Integrity Program
MFHBF	Mean Flight Hours Between Failure
MTTR	Mean Time To Replace
NDE	Non-Destructive Evaluation
NDI	Non-Destructive Inspection
OCR	Operational Capability Release
OEM	Original Equipment Manufacturer

PHM	Prognostic Health Management
PIDS	Prime Item Development Specification
POD/CL	Probability Of Detection/Confidence Level
RCM	Reliability Centered Maintenance
RFP	Request For Proposal
RPM	Revolutions Per Minute
RDT&E	Research, Development, Test & Evaluation
SPO	System Program Office
SRB	Safety Review Board
TAC	Total Accumulated Cycle
TCTO	Time Compliant Technical Order
TMF	Thermal-Mechanical Fatigue
TOW	Time On Wing
TRR	Test Readiness Review
TTP	Technology Transition Program
USAF	United States Air Force
V_{mca}	Air Minimum Control Speed
VCRM	Verification Cross-Reference Matrix
V/STOL	Vertical/Short Take-Off and Landing

3.2 Definitions.

3.2.1 Air minimum control speed (Vmca). Air minimum control speed is the minimum airborne speed with takeoff thrust or power at which the engine most critical to air vehicle control can fail and directional control can be maintained for a specified altitude, weight, and configuration.

3.2.2 De-rating. De-rating is the process of operating an electrical component well inside its normal operating limits to reduce the rate at which the component deteriorates. This is done to enhance the component's useful life. Example: If a diode is specified to be able to operate at 10V and 5 Amps, and it is placed into operation where it only sees 7V and 3 Amps, it is said to have been de-rated for that application.

3.2.3 Design Target Risk (DTR). The DTR is an agreed-to standard for assessing components using a probabilistic design system which has been validated against specimen data and component field experience. This standard is stated in terms of a component or aerodynamic stage (excluding airfoils) event rate. The component DTR corresponds to the maximum allowable predicted component event rate. Designs must satisfy the component DTR to be considered acceptable. Recognizing the current level of maturity of probabilistic design systems, the DTR and results of the probabilistic assessments are not used to show compliance to the System Safety/Reliability Requirements.

3.2.4 Economic Life. Economic life is the operational life indicated by the results of the durability test program. The economic life of the engine component has been attained with the occurrence of widespread damage, which is uneconomical to repair and, if not repaired, could cause functional problems which affect operational readiness. This can generally be characterized by a rapid increase in the number of damage locations or repair costs as a function of cyclic test time.

3.2.5 Modal Assurance Criteria (MAC). Modal Assurance Criteria is a methodology to validate the accuracy of analytically-predicted mode shapes by comparing the Finite Element Model (FEM)-generated mode shapes to measured component mode shapes from scanning laser vibrometry or similar experimental methods. (For more information on MAC, see "Shock and Vibration Handbook," Cyril M. Harris, 4th edition, McGraw Hill, New York, 1995, and its cited references).

3.2.6 Pacer program. Lead-the-Fleet (Pacer) programs are used by the USAF to determine actual distress modes of an engine in the field. This best practice describes the methods and practices used to conduct a Pacer program and how to use the results to manage the fleet safely. Technical experts examine the individual components/parts of an engine to make Analytical Condition Inspections (ACI) for managing the life of an engine.

3.2.7 Reliability Centered Maintenance (RCM). The RCM approach assumes no prior knowledge of the components, a so-called zero-based or first principles approach. Each component in the aircraft is systematically analyzed to identify its failure modes and appropriate maintenance tasks are then assigned.

3.2.8 Robustness. Robustness is the quality of being able to withstand stresses, pressures, or changes in procedure or circumstance. A system design may be said to be "robust" if it is able to function well with variations (sometimes unpredictable variations) in its operating environment with minimal damage, alteration, or loss of functionality.

3.2.9 Stress Intensity Factor (K_{1C}). Stress Intensity Factor, K_1, is a fracture mechanics parameter to characterize the stress state (“stress intensity”) near the tip of a crack caused by a remote load or residual stresses. When this stress state becomes critical, that is when $K_1 = K_{1C}$, a crack will grow (“extend”) and the material will suffer catastrophic failure. The load at which this failure occurs is referred to as “the fracture strength” and will depend on the size of the crack. The experimental fracture strength of solid materials may be 10 to 1000 times below the theoretical strength of an uncracked material, dependent on crack size. Tiny internal and external surface cracks can lower the theoretical strength of a material up to the point where the size of the crack is as small as the inherent microstructural defects in a real material. Below this size, they are of no importance in engineering design.

3.2.10 Up-rating. Up-rating is the process of operating an electrical component outside/beyond the manufacturer recommended operating range. This is usually done to minimize design cost or weight or prevent obsolescence. It may have detrimental impacts on component useful life and requires careful analysis of its application. Example: If the manufacturer specs a diode to operate at 10V and 5 Amps and it is used in an environment of 13V and 7 Amps, it is said to have been up-rated for that application.

3.2.11 Verification Cross-Reference Matrix (VCRM). The VCRM is a matrix that relates controls and/or other component requirements to higher-tier requirements.

4. GENERAL REQUIREMENTS.

4.1 PSIP overview. The effectiveness of any military force depends on the mission effectiveness and operational readiness of its weapon systems. A major factor which affects readiness and mission reliability is the integrity (including durability, safety, functionality, operability, performance, reliability, supportability, etc.) of the various systems, subsystems, and components that comprise the total weapon system. The USAF has adopted the “Integrity Process” as a key method to develop economically, achieve, verify, and maintain required capability for the various elements of the weapon system. This “Integrity Process” is derived from the system engineering process as applied to weapon system development. It was first employed in the late 1950’s for the highly-successful Aircraft Structural Integrity Program (ASIP). Although originally conceived to address safety issues with primary structure, ASIP now addresses the economics and durability aspects of operating, maintaining, and supporting the airframe. It is this broader emphasis that allowed ASIP to become such an effective and responsive approach. Integrity processes have subsequently been developed for the following: Avionics Integrity Program (AVIP) for avionics and electronics, Mechanical Equipment and Subsystems Integrity Program (MECSIP) for mechanical equipment and subsystems, and Engine Structural Integrity Program (ENSIP) for engines. This PSIP standard represents a significant increase in scope, extending the integrity-by-design methodologies described above to the performance, operability, and functional capabilities of the overall propulsion system; and engine subsystems, controls, accessories, and externals (controls and subsystems). This expansion was accomplished by incorporating the relevant criteria from the highly-successful ASIP, AVIP, MECSIP, and ENSIP.

4.2 PSIP goals. The PSIP is an organized and disciplined engineering and management process to assure that the integrity of the engine is achieved in the development program and maintained throughout operational service. The PSIP process consists of phased tasks that increase knowledge of the true characteristics of the propulsion system being developed. The goal of the PSIP process is to use the knowledge gained from these tasks to balance cost and risk and maximize product maturity. The phased tasks will focus on the following:

a. Application of a disciplined “system engineering approach” to design and development with emphasis on determining and understanding failure processes and consequences on operational performance.
b. Understanding the total system operational and support needs and the development of subsystem and component requirements and characteristics to assure that these needs are met.
c. Emphasis on realistic integrity requirements, required operational service life, required performance/operability/functionality, understanding of usage and environments (including maintenance and support) as the basis for design and qualification.
d. Early trade studies to evaluate operation and support factors together with cost, weight, and performance, and to ensure compatibility between design solutions and support equipment needs and maintenance concepts.
e. A disciplined design and development process scheduled to assure early evaluation of component response to design usage, material characteristics, manufacturing processes, and the establishment of operational limits (failure modes and service lives) in terms of design usage.
f. An integrated analysis and ground test program to evaluate design performance and integrity characteristics and to verify requirements.
g. Application of standardized test and evaluation methods to assess technical and program risk.
h. Scheduling of tests and demonstrations to assure that test findings are incorporated into design in advance of major economic and/or qualification initiation and production commitments.
i. Quality assurance strategy with special emphasis on planning, supplier quality, control of manufacturing variability, failure investigation, and corrective action to assure quality and integrity of hardware throughout production.
j. Development of force management requirements (including maintenance and inspection requirements) based on the results of the development process.
k. Follow-up control for the fielded engines through maintenance, inspection, and data gathering.
l. Investigation of the need to track usage on components and subsystems in service.
m. A program to accomplish force management.

4.3 General description of the primary PSIP tasks. The PSIP follows a five-task element approach. This approach has been derived from the systems engineering process. The systems engineering process is shown on figure 1. Systems engineering begins with the definition of top-level system requirements, allocating those requirements to a lower level, designing hardware to meet the requirements, followed by verification that the requirements have been met. And, as the figure indicates, the process can be iterative.

The five-task PSIP approach accomplishes the systems engineering process. As the tasks are accomplished, knowledge of the system characteristics increases. The PSIP represents a logical, methodical, technically-sound development strategy in which engineering assumptions are verified and component limits are accurately defined before parts are released to production. Potential failure mechanisms are identified, understood, and controlled. Increased emphasis is placed on performing early analyses and conducting incremental engineering development tests to verify analytical assumptions. The process also emphasizes that sufficient knowledge is gained on engine components in support of major program milestones and suggests that performance and durability tests that simulate realistic operating environments are one way to demonstrate that knowledge.

A general description of the five integrity tasks is given in the following sections. Engineering judgment needs to be used to tailor these tasks to fit the needs of each unique program. Knowledge-based criteria should be the basis of any engineering judgment used to tailor the PSIP, and should be clearly communicated in the initial PSIP Master Plan and any updates. New engine programs may need to do most, if not all, of the sub-tasks outlined here. Derivative programs may need only a smaller sub-set. The sub-tasks descriptions which follow are not intended to be all-inclusive, but rather to represent considerations for typical engine development. The major sub-tasks or elements contained in each of the five tasks are described in subsequent sections.

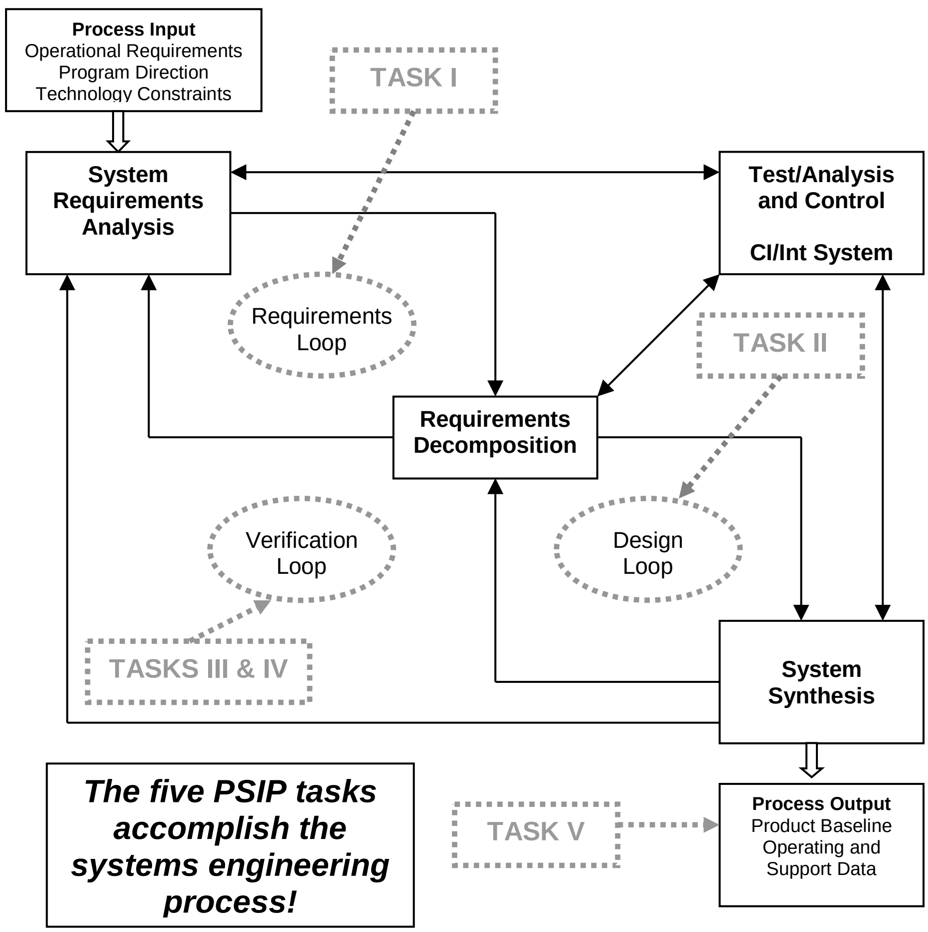

FIGURE 2. Relationship between PSIP and systems engineering.

4.3.1 Task I: Design Information and Development Planning. The development of design information is the initial step in the engine development program. The contractor shall develop and implement a PSIP Master Plan which clearly defines the knowledge needed in the Engineering and Manufacturing Development phase, the tasks needed to obtain that knowledge, and optimizes and identifies required resources. Tasks should be scheduled using an event orientation (i.e., effort directed toward the accumulation of specific knowledge, such as that needed for Preliminary Design Review, Raw Material Ordered, Procurement Specifications Issued, First Engine to Test, etc.). The Master Plan addresses all aspects of the development program and allows identification of all influences on design program initiation.

Definition and refinement of requirements are critical to the development of design information. Requirements define the product desired and product development cannot proceed until these are understood and assessed. Preliminary requirements are used to develop design concepts that are evaluated using trade studies. Initial propulsion system usage definition will be supplied by the Procuring Activity. The potential to meet performance, functional, and life requirements is assessed. Risk and cost considerations are also weighed. Safety and hazard assessments are used to define part criticality. The most stringent design criteria are applied to those parts classified as safety or mission critical. Requirements are refined and modified to reflect what can be realistically accomplished within program technical, cost, and schedule constraints. Detailed design criteria and design usage will be applied during engine material selection and design to enable the propulsion system to meet operational needs and requirements.

4.3.2 Task II: Design Characterization and Analysis. Knowledge of the engine operating environments and expected usage is required to support hardware design and definition. Environments include operating environments internal to specific equipment (i.e., pressures and temperatures inside an engine, a module, or a component such as a fuel or oil pump) and the installation or external environment which includes both natural and induced environments surrounding, entering, or acting on the equipment through airframe interface connections. Various analyses are conducted to characterize the environments, thus providing the knowledge needed to proceed with hardware design.

Performance and operability analyses serve a two-way function: top-level system requirements are allocated to the component and subsystem level, while the resulting detailed component designs are evaluated for their connectivity to system-level requirements.

Equipment usage during operational missions over a full life must be described and characterized to support design development. Descriptions of equipment steady-state and cyclic mission usage must be detailed at the engine and component levels in parameters which most significantly measure the impact of that usage. Analyses of equipment durability, life capability, strength, damage tolerance, and reliability depend on the availability of this data.

4.3.3 Task III: Components and Subsystems Testing. Rig, component, system, and core engine tests are accomplished as needed in advance of full engine testing for purposes of developing and evaluating critical design features and substantiating engineering assumptions used in analysis of various engine systems. This incremental approach allows the design to be changed or refined if needed before significant resources and development time are expended. Testing at the component and core levels allows more focused attention on specific design details due to increased instrumentation, special test setup, and orientation of test procedures. Rig, component, system, and core engine tests should be limited to those necessary to reduce the overall engine development cost and schedule of achieving requirements. Reducing the risk to the overall engine program cost and schedule should be the primary driver for adding tests to an engine development program. The operating environment of the rig, component, system, and core engine tests should be considered in evaluating the knowledge gained during the tests. The applicability of the test data to the engine design is directly impacted by the relevance of the internal and external operating environments.

4.3.4 Task IV: Propulsion System Ground and Flight Testing. Full-scale ground and flight tests are typically conducted to provide the last increment of knowledge needed in the Engineering and Manufacturing Devlopment (EMD) phase. These engine tests are performed to verify the environment in the full-scale engine under steady-state and transient conditions and to demonstrate capability. Ground testing usually includes testing at facilities able to simulate altitude conditions. Types of tests to be performed will include: performance, operability, functionality, and failure detection and accommodation (FDA) demonstrations; propulsion/air vehicle integration testing; vibration, acoustics, temperature, and flutter surveys; external components resonant tests and clearance control tests; AMTs/ASMETs; installed engine tests; and maintainability demonstrations. These tests will include measurement of steady-state and transient conditions including shutdown and cool-down parameters.

4.3.5 Task V: Engine Life Management. This task provides the operating limits and formulates plans for production, quality control, integrated logistics, and component life management (i.e., how component integrity will be preserved throughout the operational lifetime of the engine).

Design analyses are updated as required to account for production configuration design changes and differences between analytical predictions and thermal/environment/load surveys and test results. The updated analyses and test results will verify design acceptability and help establish initial inspection and repair limits for critical components. Required maintenance actions (component inspection, repair, or replacement requirements) are defined to assure adequate structural integrity and operational readiness of each engine for the design service life. Equipment monitoring systems for tracking equipment usage (i.e., mission utilization recorders and critical parts (tracking system) should be procured or developed so that the USAF can identify when to accomplish life management activities). Life maturation programs are implemented to discover design deficiencies and wear-out problems as early as possible. A means to address deficiencies and upgrade hardware to improve reliability and maintainability, and reduce total ownership cost should be defined in the Engine Life Management Plan (ELMP).

4.4 Specific requirements for Task I. The following paragraphs cover the specific requirements for PSIP Task I. These requirements universally apply to each functional section (structures, performance and operability, and controls and subsystems) in section 5 of this document.

4.4.1 Design criteria.

4.4.1.1 Requirements definition. All requirements which affect the design shall be identified. This includes program specifications and could include, but not be limited to, Interface Control Documents (ICDs), environmental, regulatory, internal design practices, and cost/schedule considerations. A matrix of the requirements and methods of verification shall be developed. Joint Service Specification Guide JSSG-2007 provides guidance for establishing the requirements.

4.4.1.2 Robustness assessment. A robustness assessment of the propulsion system shall be performed early in the program. This assessment is needed for a new centerline engine design. New centerline engines are very time-consuming and expensive to develop. The core or other technologies of these engines may be used in derivative engines in other future weapon systems. It is advantageous to the Government in the long term to include some level of robustness in the baseline design of a new centerline engine. Aspects of robustness could include thrust growth, operation outside the existing flight envelope (higher altitudes, higher ambient temperatures), mission changes, etc. The assessment shall provide the trade space and margin available in the current design, and program impacts if various aspects of robustness are included in the baseline design. The focus areas for the assessment shall be negotiated with the Procuring Service. Such an assessment is needed early in the program so that specific areas of robustness, if desired by the Procuring Service, can be allocated to the design requirements.

4.4.2 Program control.

4.4.2.1 Requirements management. A method to manage the pedigree and evolution of requirements shall be developed.

4.4.2.2 Technical reviews. Criteria shall be developed that describe the content and level of completion of each PSIP task for each program milestone. These criteria shall be used in a gated technical review process to proceed from one program milestone to the next. The intent of these criteria is to show the level of knowledge attained for the propulsion systems characteristics, and that this level of knowledge is sufficient to proceed toward the next milestone. The tables in Appendix A shall be used as a guide to create these criteria.

4.4.2.3 PSIP Master Plan. The PSIP Master Plan shall be integrated into the Integrated Master Plan (IMP) and Integrated Master Schedule (IMS). The purpose of the PSIP Master Plan is to define and document the specific knowledge needed in the Engineering and Manufacturing Development Phase. The approach to portray this knowledge will be to define specific PSIP tasks for the system being developed. The plan shall depict the time-phased scheduling and integration of all required PSIP tasks for design, development, qualification, and tracking of the propulsion system. The plan shall also include discussion of unique features, exceptions to this standard and the associated rationale, and any problems anticipated in the execution of the plan. The development of the schedule shall consider all interfaces, the impact of schedule delays (e.g., delays due to test failure), mechanisms for recovery programming, and other problem areas. The plan and schedules shall be updated with the concurrence of the program office when significant changes occur. The PSIP Master Plan shall include the intent and content of only those lower-tier plans appropriate to the product being developed. Lower-tier plans would include, but not be limited to, the following:

a. Technology Transition Plan (Includes Aero/thermo database description)
b. Corrosion Prevention/Control Plan
c. Non-Destructive Inspection (NDI) Plan
d. Materials Characterization Plan
e. Durability and Damage Tolerance Control Plan
f. Engine Structural Maintenance Plan
g. Engine Life Management Plan
h. Critical Item Control/Tracking Plan
i. Performance/Operability Plan
j. Ground Test Facility and Instrumentation Development Plan
k. Integrated Component, Subsystem, Rig, Core, and Engine Test Plan
l. Deterioration Control Plan
m. Performance Growth Plan
n. Control Development Plan
o. Diagnostics Prognostics Plan
p. Software Development Plan
q. Flight Clearance Plan
r. Weapon System Integration Plan (includes installed performance/operability methodologies)
s. Risk Management Plan
t. Reliability and Maintainability Plan
u. Manufacturing Plan
v. Obsolescence Management Plan
w. Logistics Support Plan
x. Force Maintenance Plan
y. Supplier Management Plan
z. Quality Control Plan
aa. Anti-Tampering Plan
bb. Universal Identification Plan
cc. Survivability Development and Verification Plan
dd. Vulnerability Program Plan.
ee. Cybersecurity Plan.

5. DETAILED REQUIREMENTS.

Detailed Requirements for PSIP Tasks II through V for three propulsion functional areas are provided in the following sections. The functional areas covered in PSIP are: engine structures, performance and operability, and controls and subsystems.

5.1 Structures. The structures discipline deals with the mechanical design of all the engine rotating and static hardware. The focus is on insuring the durability and robustness of the propulsion system under the various imparted loads and mission usage including aero, thermal, pressure, centrifugal, gyroscopic, maneuver, and acoustic inputs. The design must also have the capability to withstand various potential failure conditions such as overspeed and overtemperature, containment and blade-out, unbalanced loads, surge/stall events, and manufacturing- or handling-induced material defects including the probabilistic aspects of all of these items. The structures discipline is active through all phases of the engine life cycle from design, development, qualification, production, and especially to field life management.

5.1.1 Task II: Design Characterization and Analysis. The engine developer design system, or Engineering Standard Work (ESW), is the collection of engineering practices that have been validated and proven effective in the design, development, manufacturing, and sustainment of gas turbine engines. The development tests are one of the methods of acquiring data to verify that individual parts, components, assemblies, or engines meet the criteria established in the design system. The objectives of the design system and development tests of Task II are to:

a. determine the mission usage requirements and the environments in which the propulsion system must operate such as: loads, temperature, ambient environment conditions, vibratory, and acoustic environment;
b. design parts and components, accounting for steady-state, transient, and hot and cold tolerance stack-ups, and perform analysis in accordance with the design system;
c. verify conformance to the ESW design system;
d. conduct development tests to validate the design system and verify individual part/component design.

MIL-HDBK-1783 and JSSG-2007 should be used as guidance for Task II.

5.1.1.1 Design duty cycle. A design duty cycle(s) shall be derived from the design service life and design usage provided in the contract specifications. If design usage requirements are not specified by the Procuring Activity, the contractor shall convert the airframe mission profile information supplied by the Procuring Activity to engine usage profiles. The design missions shall include the mission flight profiles, thrust required/thrust available, pressure/temperature operating envelopes, mission times, and mission mix. The design duty cycle will be used to design the individual parts and components to assure the engine meets life requirements. The design duty cycle shall be updated due to significant changes in aircraft weight or drag growth and flight maneuver loads, or significant changes to the mission mix.

5.1.1.2 Material characterization. Material, including composite material structural properties, shall be established by test and approved analytical property modeling procedures early in engineering and manufacturing development. Existing design handbook data will be used where it is adequate. Material structural properties required for operations beyond the published data (particularly, pressure and temperature) shall be quantified by test and analysis. Metallic material structural properties for specific crystal orientations must establish adequate grain boundary criteria. Composite materials shall be characterized for the specific application to include design geometry as well as operational temperature and loading extremes. The material properties that are not adequately characterized will become part of the Materials Characterization Plan. Thus, the design system will rely on the materials characterization database to design parts and components which provide a high degree of confidence that specification requirements will be met. Anticipated model property capabilities should be thoroughly verified through the full range of usage combinations expected, including achievable usage extremes, during fleet operation. Material properties characterized by test through the above plan should reflect the potential impact of manufacturing operations, as appropriate. Material properties shall be established by test based on specimens fabricated from as-produced parts, or from parts produced by equivalent production practices.

5.1.1.3 Structural design system analysis.

5.1.1.3.1 Parts classification criticality analysis. All engine parts shall be classified for criticality. The classifications shall be safety critical, mission critical, durability critical, and durability non-critical. A failure mode, effects and criticality analysis (FMECA); a safety/hazard assessment; or other engineering analysis shall provide the basis for classification. This classification should be augmented by historical records and experience gained during development tests.

5.1.1.3.2 Thermal analysis. The internal environment of the engine shall be characterized for both steady-state and transient conditions for each critical point in the flight envelope. Thermal heat transfer models shall be generated for the engine static and rotating structures. The model shall have the capability to predict component nodal temperatures as a function of flight conditions via the engine performance deck. This information shall be used for component stress and life analyses, selection of critical structural design development tests, and selection of conditions to be used in the component and engine structural tests.

5.1.1.3.3 Strength analysis. Strength analyses shall address such topics as: blade and disk deflection, containment, blade-out, overspeed/overtemperature, disk burst, output shaft torque/speed limits, pressure vessels, pressure balance, gyroscopic moments, bird and ice ingestion, main and ground handling mounts, and engine stiffness. Limit and ultimate loading conditions shall be assessed and factors of safety utilized consistent with MIL-HDBK-1783 guidance.

5.1.1.3.4 Stress analysis. Stress analysis shall be conducted which establishes the stresses, deformation, and margins-of-safety resulting from the loads and temperatures imposed on the propulsion system and all critical components, including blade internal cooling features. In addition to verification of strength margins, stress analysis shall be used as a basis for durability and damage-tolerance analyses, selection of critical structural design development tests, and selection of loading conditions to be used in the component and engine structural strength tests. The stress analysis shall also used as a basis to determine the adequacy of structural changes throughout the life of the propulsion system, material review actions, and to determine the adequacy of the engine for new loading conditions which result from increased performance or new mission requirements.

5.1.1.3.5 Durability analysis. Durability analysis shall substantiate the ability of the structure to comply with engine life requirements. The design duty cycle shall be used in the development of the durability analysis and verification tests. All durability analysis approaches, except high cycle fatigue (HCF), shall account for factors that affect the time for cracks or damage to reach a magnitude large enough to cause uneconomical functional problems, repair modification, or replacement. These factors include operating temperatures and pressures, loading sequence and possible environmental interaction effects, material property variations, and possible manufacturing impacts. In addition to providing analytical assurance of a durable design, the durability analysis shall provide a basis for development of test spectra to be used in the component and full-scale engine durability tests. This activity includes any analyses used to verify the durability of the design for safe-life-related structural failure modes that include, but are not limited to, low cycle fatigue (LCF), thermal-mechanical fatigue (TMF), dwell fatigue, oxidation erosion, bearing spallation, and wear. Some of these analyses are calibrated directly to test results and may be considered as part of the corresponding component or engine test evaluation. High cycle fatigue analyses shall be conducted in accordance with 5.1.1.3.10.

5.1.1.3.6 Damage tolerance analysis. Damage tolerance design and analyses shall be conducted to substantiate the ability of the identified safety- and mission-critical structural components to continue to perform safely in the presence of material, manufacturing, processing, or handling- or operationally-induced damage for the minimum required maintenance-free period of unrepaired usage. The achievement of adequate damage tolerance is not limited to classical analytical fracture mechanics techniques. Methods of achieving damage-tolerance compliance include: controlled crack growth, fracture screening, damping, adequate frequency margin, proof testing, adequate design margin, redundancy, leak-before-burst, composite impact damage, other hazard controls, similarity (legacy systems), and, if none of the above methods can be accomplished, remote probability of occurrence analysis with Procuring Activity approval.

The specification design usage shall be the basis for load spectrum development to be used in the crack growth analysis and verification tests. The calculations of critical flaw sizes, residual strengths, safe crack growth periods, and inspection intervals shall be based on pertinent design handbook fracture test data and any additional crack growth rate data generated as a part of the design development test program. Fracture mechanics analyses performed for damage tolerance should use linear elastic fracture mechanics as the basis of the analysis method. Any additional methodology considerations should be supported by appropriate data. In general, these considerations would include time-dependent crack growth, effects of out-of-phase stress and temperature, load interaction (overload crack retardation and/or under-load crack acceleration), and consideration of residual stress fields due to surface treatments (e.g., shotpeen).

5.1.1.3.7 Damage tolerance action categories and guidance. The most appropriate damage tolerance approach shall be selected for each component based on its design, manufacturing method, application, and material, with the approval of the Procuring Service.

5.1.1.3.7.1 Controlled crack growth (fracture analysis). Crack growth analysis and/or sub-element/component crack growth testing shall demonstrate that the residual strength capability is maintained for the crack growth service life requirement. The initial flaw size used is the flaw size consistent with the specified inspection process and resultant demonstrated required reliability-based probability of detection/confidence level (POD/CL) capabilities.

5.1.1.3.7.2 Fracture screening. Crack growth analysis or sub-element/component crack growth testing shall demonstrate that the residual strength capability is maintained for at least two times (2X) the design service life. For analysis, the typical flaw sizes used are 0.035x0.070-inch surface flaws or 0.035x0.035-inch corner flaws and require no special, enhanced non-destructive evaluation (NDE) reliability-based inspection demonstrations or damage tolerance control actions. This requirement is also met by designs that show no crack propagation (i.e., below the threshold stress intensity factor for the limit load condition). This approach will not be used on airfoils.

5.1.1.3.7.3 Fracture screening for airfoils. Crack growth analysis or sub-element/component crack growth testing shall demonstrate the residual strength capability is maintained for at least 1 times (1X) the design service life for cold parts and for 1 hot section design life for hot parts. For analysis, the external surfaces for a typical blade will be assessed assuming initial flaw sizes of 0.005x0.010 inches for surface flaws or 0.005x0.005 inches for corner flaws. These initial flaw size criteria are recommended based on experience with successful airfoil designs. No special, enhanced NDE, reliability-based inspection demonstrations are required. The crack growth assessment will be conducted under pure LCF and TMF loading of the Duty Cycle, with the “critical” flaw size defined as that associated with the onset of HCF growth under the maximum loads and corresponding stress ratio, R, of the Duty Cycle. Shotpeen benefits may only be considered if validation data is available. Embedded defect analysis is not required. Surface zones treated by well-controlled processes producing deep (deeper than conventional shot peening) compressive residual stresses (e.g., laser shock peening (LSP) or low plasticity burnishing (LPB)) may produce a fully-damage-tolerant condition. In such cases, if validation data is available, no further analysis is required. Through analysis, testing, or similarity considerations, it shall be shown that the surface treatment procedure does not produce detrimental effects—neither stress fields or deformations—in regions away from the treated area due to the tensile residual stresses developed in the process. This requirement is also met by designs which show no crack propagation (i.e., below the threshold stress intensity factor for the limit load condition).

5.1.1.3.7.4 Fracture screening for turbine blade roots. Crack growth analysis or sub-element/component crack growth testing shall demonstrate that the residual strength capability is maintained for at least 1 hot section design life. For analysis, the external surfaces below the blade platform for a typical blade will be assessed assuming initial flaw sizes of 0.005x0.010 inches for surface flaws or 0.005x0.005 inches for corner flaws. No special, enhanced NDE, reliability-based inspection demonstrations are required. The crack growth assessment will be conducted under pure LCF loading of the Duty Cycle, with the “critical” flaw size defined as the smaller of that associated with K_{1C} or tensile rupture. Shotpeen benefit may only be considered if validation data is available. Embedded defect analysis is not required. This requirement is also met by designs which show no crack propagation (i.e., below the threshold stress intensity factor for the limit load condition).

5.1.1.3.7.5 Redundancy. Redundancy in design incorporates dual/multiple components or duplicates function to provide operational capability (without degradation) upon failure of a single component or function. Failure of a single component or function must be detectable (i.e., system is both fail operational and fail evident). Detectability may be through the Prognostic Health Management (PHM) system or at depot inspection. Redundancy also may apply to a component that has redundant features.

5.1.1.3.7.6 Damping. Damaging modes of vibration are addressed through detuning and/or the incorporation of damping features. Testing of the design is required.

5.1.1.3.7.7 Adequate frequency margin. Damage tolerance with respect to vibratory stresses is achieved by ensuring the component has sufficient frequency margin relative to responsive engine orders and adjacent hardware. Modal testing is required in addition to analysis. This is typically applied to components not in the gas path. This methodology is not applicable for airfoils (see 5.1.1.3.7.3).

5.1.1.3.7.8 Proof testing. A test is performed on each production component that can effectively demonstrate that the part is damage tolerant. The proof test must be supported by analysis.

5.1.1.3.7.9 Leak before burst. Fracture mechanics analysis shall confirm that a through crack in a fluid container will leak fluid before burst by demonstrating tolerance of a through thickness crack two times (2X) the wall thickness, or a size agreed upon with the Procuring Service, when subject to limit loading conditions.

5.1.1.3.7.10 Composite impact damage. For traditional composites (e.g., organic matrix composite), composite component or representative sub-element shall demonstrate functional/structural integrity after sustaining either 100 ft-lbs kinetic energy from a 1.0-in-diameter solid hemispherical impactor or the kinetic energy required to cause a dent 0.10-in. deep, whichever is less, for a minimum period of two inspection intervals (for depot inspectable parts), or two times (2X) the design service life (for non-inspectable parts). The impact damage shall be supplemented with environmental considerations such as moisture and temperature exposure. It should be shown that impact damage that can be realistically expected from manufacturing and service, but not more than the established threshold of detectability for the selected inspection procedure, will not reduce the structural strength below ultimate load capability. This can be shown by analysis supported by test evidence, or by tests at the coupon, element, or sub-component level. In some cases, an assessment may be performed to determine the impact energy representative of operational conditions instead of the values listed above.

For ceramic matrix composite (CMC) components in the gas path (e.g., airfoils), composite component or representative sub-element shall demonstrate functional/structural integrity after sustaining representative manufacturing-, maintenance-, and/or service-induced damage, for a minimum period of two inspection intervals (for depot inspectable parts), or two times (2X) the design service life (for non-inspectable parts).

5.1.1.3.7.11 Adequate design margin. This approach shall not be used as the sole damage tolerance action of safety-critical parts. Components subjected to LCF loading shall demonstrate by test or analysis a minimum LCF life of not less than four times (4X) the design service life. Components subjected to vibratory loading shall demonstrate the appropriate stress margin to the endurance limit of the material, based on the Goodman Diagram. This approach is typically used where other approaches are not feasible or appropriate.

The analytical approach may be used for components designed for loading requirements such as blade-out, stall, HCF, etc.

5.1.1.3.7.12 Similarity (legacy systems). Similarity is applicable when significant, successful operational experience on hardware of actual or similar design and usage has occurred. This approach is used where other approaches are not feasible/appropriate, and is appropriate for mature designs susceptible to damage. It shall be the first option considered for "non-traditional" damage-tolerance components. The following shall be considered to establish similarity:

a. materials and processing;
b. design configuration and usage;
c. operating environment considerations including cycle temperatures and pressures, speeds, torques, and flows;
d. legacy component hours or cyclic history, including number of parts produced, number and type of safety-critical or mission-critical events, total number of fleet hours, and high-time component.

5.1.1.3.7.13 Other hazard controls. Other hazard controls are special controls applied when the failure mechanism does not involve LCF-induced crack growth.

5.1.1.3.7.14 Improbable occurrence. An improbable occurrence is defined as a risk of failure shown to be less than $1x10^{-7}$ events per engine flying hour (EFH). This approach may be used to satisfy damage-tolerance concerns for components where other established approaches do not exist.

5.1.1.3.8 Probabilistic analysis. Probabilistic analysis may be used for durability and damage tolerance analysis. For parts designed with probabilistic methodology, the lives associated with design service life are replaced by a total life requirement that the combined component or aerodynamic stage (excluding airfoils) failure rate for all selected structural requirements shall not exceed a DTR defined by the program. (This DTR was set at a value of $5x10^{-8}$ predicted occurrences per EFH for a recent, advanced single-engine fighter.) HCF shall not utilize probabilistic analysis. This analysis shall use a validated probabilistic design system of the original equipment manufacturer (OEM), as specified in the PSIP plan, provided system-level safety requirements are met. In addition to the above DTR, probabilistic designs shall meet minimum deterministic requirements of an LCF durability life equal to or greater than one design service life, and a damage tolerance safety limit capability equal to or greater than 1.5 times (1.5X) the inspection interval for the NDE-demonstrated initial flaw size. These deterministic requirements may change as more experience is gained in probabilistic analysis or fleet maturity warrants.

5.1.1.3.9 Creep analysis. Creep and stress rupture analyses are required to substantiate that engine operation is not impaired during service operation and that part replacement is not required during the part life interval.

5.1.1.3.10 Vibration, flutter, and HCF analysis. The objective of the analyses is to ensure the propulsion system is resistant to vibration-induced fractures throughout the design service life. The analyses shall characterize the environment from potentially-critical sources and shall determine the part, component, or system dynamic response, including aero-thermal and damping effects. Potentially-critical sources of excitation may include, but are not limited to, blade and vane passing frequencies, inlet distortion, rotor unbalance, noise, regions of turbulent and separated flow, exposed cavity resonance, seal and seal cavity resonance, and pump pressure pulses.

5.1.1.3.11 Containment analysis. Containment is an interface requirement and shall be allocated from the weapon system requirements. The engine shall have full containment unless this requirement's allocation is split between the engine and the airframe. The full allocation requirement for containment shall be to ensure failure of a rotating component poses a minimum catastrophic hazard due to secondary damage, or probability of failure for a component is low enough to be considered unlikely. Analytical predictions shall be validated against rig or full engine tests of equivalent hardware.

5.1.1.3.12 Engine life and sensitivity analysis. Engine life analyses will be conducted to establish a baseline and limits for operational usage of the engine. Sensitivity analysis shall be conducted on components to identify the effect of probable ranges in usage variables on engine life limits. Sensitivity analysis will be tailored to the specific program and be done in accordance with OEM design practice and agreement with the Procuring Activity. Usage parameters to be considered in the sensitivity analysis should include mission, airspeed, altitude, ambient temperature, full and partial throttle cycles, and dwell times at minimum and maximum power levels. An example is an increase in turbine inlet temperature that significantly reduces the life of the turbine. The engine life analyses including probabilistic assessments will become part of the Engine Life Management Plan (ELMP) and be used throughout the development, acquisition, and sustainment phases of the engine program.

5.1.1.4 Manufacturing and quality assessment. An assessment of the manufacturing and quality system shall be conducted to ensure the OEM manufacturing and quality systems can consistently produce parts able to meet all specification requirements throughout the ground and flight operation. The assessment shall also include inspection capability and repairability as required to be consistent with damage tolerance actions.

5.1.1.5 Design development tests. The objectives of design development tests are to verify pre-test predictions, and to obtain early evaluation of the design system. Examples of design development tests are tests of wear coupons, small elements, joint configurations, fittings, actuation system components, damper tests, seal tests, and process development tests. System, rig, and engine component tests may be accomplished as part of the design development testing. The scope of the proposed test program shall be included in the PSIP Master Plan.

5.1.2 Task III: Components and Subsystems Testing. The objective of this task is to assist in the determination of the structural adequacy of the design through a series of component tests, core engine, and engine tests. Compressor/turbine test stands, spin pits, altitude test facilities, and ground test facilities may be required to conduct verification tests. Each test should include the objectives, rationale for the test, and lessons learned from previous testing. These tests support the determination that the propulsion structural design is adequate to meet the strength, vibration, durability, damage tolerance, and containment requirements. The testing also substantiates the analysis conducted in Task II. Guidance for the testing may be found in MIL-HDBK-1783 and JSSG-2007. Durability verification of hot section components must complete one life demonstration prior to production deliveries. Pre-test analytical predictions and post-test data updates should be included for each test. The testing provides design confirmation and risk reduction for follow-on, full-scale engine tests conducted to validate that the design system meets the operational requirements for the engine.

5.1.2.1 Structural tests. The key to engine safety, operability, and maintainability is understanding the structural capability of the engine as a whole and capability of each of its components. The following subparagraphs define the requirements to illustrate these critical ingredients of the engine's structural design capability.

5.1.2.1.1 Strength. Strength tests shall be conducted to validate component capability under limit and ultimate load conditions. Factors of safety will be utilized to set appropriate limit and ultimate load conditions. Adjustments to component test conditions (e.g., speed, temperature, load) should be used to set equivalent bench/rig conditions with required engine conditions or to account for material property variations. Containment, disk burst, shaft torque limits, pressure vessels, and mount integrity are strength requirements that may be validated through component-level testing.

5.1.2.1.2 Vibration and HCF. Vibration testing shall be conducted on components that are susceptible to vibratory-induced failure modes. High cycle fatigue testing of blades under this task may include bench testing of airfoils to validate that finite element models have accurately captured the modal response characteristics of the part. Boundary conditions and physical characteristics of the part being tested should be consistent with the model. The use of MAC via experimental techniques such as laser vibrometry measurements is recommended as a measure of the accuracy of the FEM. Rig, core engine and/or spin pit tests of fan, compressor, and turbine assemblies may be conducted to gain early insight into the aeromechanical behavior of airfoil designs. These tests shall include sufficient variation of influence parameters (revolutions per minute (RPM), temperature, pressure, distortion, vane schedule, and variable cycle features as applicable) to characterize operational extremes. High cycle fatigue test protocols developed under the High Cycle Fatigue Science and Technology Program (see MIL-HDBK-1783) should be used during the engine design and validation processes, including mistuning and/or mode localization susceptibilities.

5.1.2.1.3 Durability. Durability tests shall be conducted on all the engine components and should consist of repeated application of the design service loads/environment spectra. The objectives of the component durability tests are to:

a. Demonstrate that the economic life of the test article is equal to or greater than the design service goal by the desired margin.
b. Validate critical areas of parts and components.
c. Provide a basis for special inspections and modification requirements for development and flight test assets.
d. Validate the design system analysis.

Component tests should be of a sufficient duration to validate part life while addressing material property variation and the engine environment.

5.1.2.1.4 Damage tolerance. Damage tolerance tests shall be conducted on selected safety- and mission-critical components. The selected test components should be representative of production configuration in terms of material, manufacturing/processing, and geometry. The objectives of these tests will be to validate analytical tools and/or to demonstrate compliance with the component damage tolerance analysis described in 5.1.1.3.6.

5.1.2.1.5 Containment. Containment capability shall be demonstrated on selected safety and mission critical components. Demonstration of the containment capability may be through analysis and/or test (specimen, subcomponent, component rig or engine), or through similarity with prior validated configurations. The engine shall have full containment of selected components unless there is a split of allocation of this requirement between the engine and airframe. The full allocation requirement for containment should be to ensure that failure of a selected rotating component poses a minimum catastrophic hazard due to secondary damage, or probability of failure for a component is low enough to be considered unlikely.

5.1.2.1.6 Stiffness. The engine structure shall be tested to substantiate that the engine has enough stiffness to prevent rotating components from contacting stationary structure significantly enough to require maintenance actions. This substantiation test should address the flight, landing, and ground operations that the engine could be exposed to in the lifetime of the engine as defined in the specification. Operational clearances such as blade tips and/or seals should also be checked against specification usage requirements. All static or dynamic hardware interactions (rubs) shall be fully characterized so as to avoid adverse interactions (e.g., overheating and mechanical damage).

5.1.2.1.7 Thermal and pressure surveys. A core or full engine test shall be conducted to verify the engine cavity pressure and temperature conditions and turbine airfoil temperatures for validation of analytical models. Combustor characterization testing using sector and full annular rigs should be performed to establish pattern factor and radial temperature profiles. This data will be used in establishing the position and magnitude of turbine blade and vane temperatures. Cavity pressures and temperatures should be measured on safety- and mission-critical components to validate the analytical predictions. The tests should be validated on a rig or full engine tests of equivalent hardware.

5.1.2.2 Engine life and sensitivity analysis. Engine life analyses shall be updated to include data and information from the component, core, and system level testing. Sensitivity life analysis should be updated on components to identify the effect of probable ranges in usage variables on engine life limits. Sensitivity analysis will be tailored to the specific program and be done in accordance with OEM design practice and agreement with the Procuring Activity.

5.1.3 Task IV: Propulsion System Ground and Flight Testing. Ground and flight tests are accomplished to verify the capability of the engine to meet the certifying requirements for the engine and the weapon system. These tests are conducted on engines representative of the production configuration. Ground tests include qualification testing for performance, structures, controls and subsystems, and weapon system integration. The ground and flight engine tests are conducted to verify the engine's capability to operate in the altitude, Mach number, and environmental conditions that the aircraft will be exposed to in the performance of its missions. Production representative full-scale engines shall be tested to demonstrate the structural ability of the engine to provide mission performance and full engine life for the weapon system missions. Additionally the engine must demonstrate its ability to operate within the specification requirements after ingesting all environmental effects such as rain, ice, sand, dust, salt spray, gun gas, rocket gases, birds and other items that could enter the engine inlet. The types of tests to be performed shall include: ground vibration, temperature, and flutter surveys; external components resonant tests and clearance control tests; AMTs/ASMETs, system integration tests, and flight test. The tests shall include measurement of steady-state and transient conditions including shutdown and cool-down parameters. Installed engine tests shall be performed when installed in the flight test aircraft for initial verification of the engines capability to meet the aircraft mission requirements. Guidance for the testing may be found in MIL-HDBK-1783 and JSSG-2007. The OEM program office initiates the planning and controls the overall test plan. The test need and risk assessments should be conducted for each test to ensure appropriate data and information is obtained from the test vehicle. A tracking system should be established early in the program to track progress for test cost, program management, resources, and testing. The OEM and Lead Development Test Organization (LDTO) conduct the test, ensure accuracy of data, and prepare the test reports. Test planning and execution requires a coordinated effort by members of the Government Program Office and the OEM contractors. Regularly scheduled group coordination meetings should be conducted to define, discuss, and develop the test plan and test activities. The OEM responsibilities include the design, development, and configuration of the engine; provision of the test plan, personnel, and test hardware resources; and communication of test data requirements.

For tests, the PSIP Master Plan shall include provisions for:

a. Test rationale and risk assessments: Each test plan should include the risk assessment and the rationale for the test. This is required to minimize technical unknowns, appropriately plan the test conduct, and to minimize test costs.
b. Pre-Test Predictions. Test planning should include predictive outcomes for the test parameters with clear and measurable objectives. The use of correlations for structural programs, operability programs, and performance cycle decks should be used to ensure the engine is performing as planned and also as a means to make adjustments to the analytical programs after the test.
c. Test Readiness Reviews (TRR) and Safety Review Board (SRB). A TRR and the SRB shall be accomplished as a joint effort between the Government System Program Office (SPO), the LDTO, and the OEM. A set of TRR and SRB entrance, exit, and post test critique criteria should be established for each test.
d. Post Test Assessment. Test data should be analyzed, lessons learned documented, and results incorporated into the engine design models.

5.1.3.1 Ground engine tests. The key to engine safety, operability, and maintainability is understanding the structural capability of the engine as a whole and the first step to proving that the analysis is correct is when the engine is ground tested. The following subparagraphs will define the requirements for demonstrating that the engine design is sound and that it will be safe to fly. Engine ground tests are performed to validate analytical models and demonstrate structural integrity.

5.1.3.1.1 Thermal and pressure surveys. Instrumented engine tests shall be performed for both steady-state and transient conditions to measure internal gas stream, cooling flow cavity temperatures, metal temperatures, pressure distributions, and external temperatures for the installed configuration. Internal environment thermal and pressure surveys should be scheduled as early as possible in the development phase. Core and/or full-scale engines shall be utilized, as appropriate. Engine run conditions throughout the flight envelope should include:

a. Stabilized idle to snap/acceleration to stabilized maximum power to chop/deceleration to stabilized idle.
b. Shutdown and cool-down.
c. The planned Accelerated Mission Test/Accelerated Simulated Mission Endurance Test (AMT/ASMET) power sequence.

Thermocouple and cavity pressure measurements shall be made throughout the engine modules. Thermocouples shall be located at various radial locations on disks and on critical seals/spacers to establish gradient data.

5.1.3.1.2 Ground vibration strain & flutter boundary. Instrumented ground engine tests shall be conducted to verify the dynamic response of the total engine system. Instrumentation shall include accelerometers and proximity probes in the vertical and horizontal planes. Tests shall be conducted as early as possible on a core or engine to determine vibratory stresses and to investigate flutter boundaries. Subsequent tests shall be conducted on the full engine. Sensitivity to effects of rotor imbalance up to the maximum allowable shall be verified. The rotor(s) shall be unbalanced with the most adverse weight placement for the lowest critical speed and a phase angle predicted by analysis of residual unbalance. Magnitudes of total unbalance shall be large enough to overcome typical residual unbalances to reach maximum levels found in similar engines prior to overhaul and to reach field vibration limits. The engine should be run through the operating range to maximum power.

5.1.3.1.3 Dynamics. The dynamics of the engine are key to the safe operation of the engine and assure that engine operability is achieved and that the engine will be economically maintainable. The following subparagraphs will define the requirements for assuring the engine dynamics are within the expected range of response that the initial analysis has predicted. This testing will demonstrate the design goals have been achieved and the engine is ready for flight testing.

5.1.3.1.3.1 Rotordynamics. Instrumented engine testing shall be conducted to characterize vibration due to residual unbalance, concentricity, alignment, and stiffness effects. The results of this testing will be used to verify vibration limits and to validate rotordynamic models. Sufficient instrumentation shall be installed on the engine to fully characterize vibration in all three axes for high and low spool characterization as well as the accessory gearbox. Testing shall encompass the entire operational speed range of the engine as well as overspeed conditions.

5.1.3.1.3.2 Aeromechanics. Vibratory stress surveys shall be conducted on representative test engine(s) to characterize aeromechanical responses and validate that maximum levels meet contract specification requirements. Flutter boundaries shall be established and shall account for the effects of mis-rigging of the engine. Sufficient instrumentation shall be applied to ensure coverage for all critical modes on required stages. The HCF Test Protocol as contained in MIL-HDBK-1783 and the Propulsion Center of Excellence Best Practice PCOE BP-01-11 shall be applied to all aeromechanical testing.

5.1.3.1.3.3 Externals. A mechanical impedance/resonance search static test plan shall be developed and tests performed on external hardware and accessories. Testing requirements shall be in accordance with the appropriate paragraphs in the controls and subsystems section 5.3.

5.1.3.1.4 Strength. The engine shall be tested to demonstrate it will not exhibit detrimental permanent set when operated within the flight and ground operating envelope up to limit load conditions. Additionally, the engine shall not temporarily deform to the extent that operation or performance is significantly affected within the flight and ground-operating envelope. The engine shall not experience uncontained failures when subject to ultimate loads or combinations of ultimate loading.

5.1.3.1.5 Blade-out. Verification of the blade-out requirement shall be accomplished by a propulsion system test of the most critical rotor stage. This test may be performed in conjunction with the containment verification. The failure condition shall occur at the maximum transient rotor speed (i.e., the maximum normal operating speed plus adjustments to account for deterioration, control and measurement uncertainty. Sufficient instrumentation shall be applied to calibrate rotordynamic models for evaluation of other damage conditions.

5.1.3.1.6 Containment. Engine blade containment tests shall be conducted at or above the maximum allowable rotor speeds and maximum operating temperatures. The blades selected for the test (those blades determined to be the most critical) may be modified to fail at a predetermined speed. The test should be considered satisfactorily completed when all damage is contained.

5.1.3.1.7 Overspeed/overtemperature. Overspeed and overtemperature tests shall be conducted to substantiate/correlate analytical predictions. For the overspeed test, all rotors should be subjected to engine operation for a stabilized period of at least five minutes duration at the required margin over maximum allowable steady-state speed at the engine's maximum allowable temperature. Following the test, parts and assemblies should be within allowable dimensional limits and there should be no evidence of imminent failure. Upon successful completion of the overspeed test, the same engine shall be operated at the required temperature over the maximum allowable temperature and at no less than maximum allowable steady-state speed for five minutes. Following the test, parts and assemblies should be within allowable dimensional limits and meet the requirements of the specification.

5.1.3.1.8 Ingestion. Using the guidance provided in JSSG-2007, engine testing shall be conducted to verify analytical predictions of bird, ice, sand and dust ingestion. Inlet size and geometry may be considered when calculating the bird mass distributions at the engine face.

5.1.3.1.9 Accelerated Mission Test/Accelerated Simulated Mission Endurance Test (AMT/ASMET). Using the guidance in MIL-HDBK-1783 and JSSG-2007, AMT/ASMET shall be performed to demonstrate safe, economic, and reliable operation over the planned inspection interval and design service life of the propulsion system. Test cycles shall be based on the design duty cycle established in Task II and adjusted for appropriate acceleration factors. Testing should demonstrate two times (2X) the planned flight test program (or a minimum of 500 Total Accumulated Cycles (TACs)) for Initial Flight Release (IFR), one inspection interval for Full Flight Release (FFR), and one design service life for Initial Service Release (ISR). Testing of a production engine shall demonstrate one design service life by Operational Capability Release (OCR).

5.1.3.1.10 Damage tolerance. When specimen and component-level testing have not been accomplished to satisfy damage tolerance actions on mission- and safety-critical parts, engine testing shall be utilized to demonstrate compliance with the assigned damage tolerance actions defined in the respective paragraphs.

5.1.3.2 Weapon system integration. Ground tests shall be run to demonstrate integration with the weapon system. An instrumented engine integrated with the applicable actual or simulated weapon system interfaces (e.g., horsepower extraction from secondary power system (hydraulic and electrical), bleed air to the environmental control (pneumatic) system, inlet, exhaust, diagnostic system, and mount system interfaces), is tested at the environmental extremes to demonstrate satisfactory operation with the system utilities. The results are used to prepare for operation of the engine in the weapon system during ground and taxi tests, and ultimately flight test.

5.1.3.3 Installed engine ground and flight test. The "true" test of an engine comes when the engine is installed in the aircraft and ground tested and flown to the aircraft usage envelope and exposed to all the flight conditions. Ground engine and taxi testing shall be conducted to assure that the engine is ready for flight testing. The testing may also demonstrate the capabilities to install or remove the engine from the weapon system within the time limits required by the weapon system specifications. These tests should be accomplished on a production configuration engine to impose the effects of the nacelle and angle-of-attack during flight maneuvers that creates inlet distortion and ram conditions that cannot be fully simulated in ground engine testing during the development process.

5.1.3.3.1 Fan strain survey. An instrumented fan shall be flight tested to assure that there are no detrimental vibratory responses of the fan blades and vanes throughout the flight envelope. The engine shall exhibit positive flutter margins throughout the flight envelope.

5.1.3.3.2 Nacelle temp survey. An instrumented engine shall be ground and flight tested to assure that there are no detrimental installation temperature effects on the engine that would limit the operation and durability of the engine; or create fire potential throughout the flight envelope. The instrumented engine shall exhibit positive temperature margins throughout the engine flight envelope.

5.1.3.3.3 Installed vibration. An instrumented engine shall be ground and flight tested to assure that there are no detrimental system vibration effects on the engine that would limit the operation and safety of the engine throughout the flight envelope. The instrumented engine shall exhibit positive vibratory margins throughout the engine flight envelope.

5.1.4 Task V: Engine Life Management. Engines being fielded have completed the technology, development, and test phases of programs and are in the process of being manufactured and/or supported in the operational field arena. Engine spare parts, overhauls, and improvements are accomplished to maintain the engines in fully operable and safe condition. The issue of structural failure in fielded engines has resulted in safety issues, supply problems, and maintenance/inspection problems. These issues have resulted in the realization that very structured planning will help in the early identification, resolution, and containment of even larger problems. The goal of life management is to safely operate the engines throughout their economic lifetime, where economic means it is less costly to operate and maintain current engines versus buying new ones. The engine life management concepts have been developed and have evolved within the propulsion community to provide a roadmap of activities that must be considered for the support of the engine in the field. These activities include management of the engine hardware and field maintenance as well as management of the technology and engineering tools used to support the engine. PSIP life management planning and execution shall be accomplished.

5.1.4.1 Engine Life Management Plan (ELMP). A methodical system engineering collaborative approach shall be taken to develop the ELMP fully. The plan shall assure that planning is conducted to provide the most cost-effective management of the fleet of engines over the lifetime of individual fleet aircraft. The strategic aspects of the ELMP shall incorporate tactical milestones that include consideration of engine upgrades, maintenance/logistics criteria for redesigns to enhance support and safety, and logistics methodologies for the servicing, repair, and overhaul of the engine or components at the intermediate maintenance shop or depot. The plan shall also consider the engineering and technical tools used in support of the engine and shall establish tasks to insure these tools are kept current. The ELMP needs to be a living document that is kept current with information that management uses everyday. The ELMP shall be updated at program milestones, life changes for significant components, engine block changes, changes to key personnel, and after each significant review. The ELMP will consider the following key elements.

5.1.4.1.1 Engine structural integrity. The structural integrity for fielded engines shall consider the updates to structural analysis, the engine structural maintenance plan, operational usage surveys, individual engine tracking, durability and damage tolerance control actions and updates to technical orders.

5.1.4.1.2 Engine manufacturing and integration. To further enhance engine damage tolerance capabilities, an appropriate linkage needs to be established between engineering and manufacturing plans, to ensure that the parts are consistently produced with the attributes required by engineering.

5.1.4.1.3 Engine prognostic systems. The health of an engine shall be constantly monitored through the use of diagnostics and trending systems. Engine prognostics systems used to support the sustainment of fielded engines should be developed concurrently with the engine and used throughout the sustainment portion of an engine program. Data from these systems should be made available (in conjunction with the mission usage/life analysis data) for continued engineering analysis and monitoring. The ELMP shall incorporate the use of the trending and diagnostics efforts for sustaining fielded engines and shall include periodic engineering assessment of the data.

5.1.4.1.4 Reliability-Centered Maintenance (RCM). Reliability-Centered Maintenance focuses on preventative maintenance as a means to avoid, reduce or eliminate the consequence of failures. RCM may be defined as a disciplined methodology used to identify preventative maintenance tasks to realize the inherent reliability of equipment with the least expenditure of resources. The ELMP shall include the methodology for improving the reliability of fielded engines. Reference AFMCI21-103.

5.1.4.1.5 Analytical Condition Inspection and Pacer programs. The ELMP shall include the planned ACI and Pacer programs. Lead-the-Fleet (Pacer) programs and the subsequent disassembly and analysis of the engine components help identify weak links attributed to design or fielded operation. These programs determine actual distress modes of an engine in the field. Once the distress modes are properly identified, proper maintenance planning may be conducted to allow the engine fleet to continue to operate safely. The Fleet Leader program shall include periodic tear down and inspection of engine hardware by both the OEM and government personnel. These inspections are intended to bring experts together to examine the engine hardware looking for early indications of distress, as well as information regarding analytical model assumptions. Reference AFMCI21-102.

5.1.4.1.6 Mission usage/life analysis. The ELMP shall include plans for mission usage surveys and life analysis updates. Mission usage surveys shall be conducted at regular intervals spanning representative operational locations. Mission usage surveys are used by the USAF to determine actual usage of an engine in the field. Life analyses shall be used to update the parts lives and spare parts forecasts. Generally, the mission surveys include interviews with pilots and maintainers. In addition, actual aircraft data from daily flight operations during the survey should be made available as a key aid in discussing engine usage with pilots. This may involve downloading and processing data from the aircraft on a daily or flight-by-flight basis depending on the application. Field surveys are used in conjunction with trending and diagnostics data to provide field flight profiles as input to the Life Analysis to compare actual engine usage to the design duty cycles. Field flight profiles defined in this fashion may be significantly different than the design duty cycle. Also, as the aircraft/engine weapons system evolves to meet the requirements of the user and adjusts to changing threats/environments of operation, the engine usage will change such that critical part lives are impacted. Maintaining updated flight profiles is required to keep the life analyses current and accurate and to support safe and accurate inspection intervals and life limits. Usage of appropriate PHM lifing algorithms based on engine sensor data may facilitate accurate assessment of engine (part) life consumed that is specific to an actual flight profile. Results of the mission usage surveys and life analyses may impact inspection intervals, part lives, retirement predictions, revisions to AMT/ASMET, and spare parts forecasting.

5.1.4.1.7 Component Improvement and Sustaining Engineering Programs. Each engine program needs a source of funding for improvements and updates to fielded engines. The funding is generally used for safety, reliability, and maintainability improvements for operational engines. The USAF Component Improvement Program (CIP) has provided a source of sustaining engineering and qualification for over 40 years. The CIP Research, Development, Test & Evaluation (RDT&E) programs develop solutions to increase safety of flight, correct operationally identified deficiencies, improve reliability and maintainability and, reduce total ownership cost. CIP products include redesigned components, new repair and maintenance procedures, and other initiatives to maintain original engine specification performance. The ELMP shall include the OEM's system to upgrade fielded engines and the OEM's system for maintaining the analysis tools used to predict engine performance, temperatures, stresses, etc that are key to understanding the structural integrity of engine components. Commercial engine acquisitions and specialized tailored logistic support contracts have also been used for some programs. The programs include the sustainment engineering within the program baseline and do not rely on CIP. They still focus on reliability and ownership costs for sustaining engines in the operational environment. The ELMP shall include the government's and OEM's planned system engineering and management approach to upgrade fielded engines.

5.1.4.1.8 Business management. The business practices in managing the engine life are extremely important to ensure that the user has an engine that completes its required mission at the minimum operational cost. The business plan in the ELMP shall include the item management, scheduling, funding, spare parts, transportation, logistics, and resources to provide support for the warfighter.

5.1.4.1.8.1 Master timeline and budget. A master timeline and budget must be established for each fielded engine. The budget should include the last 5 years of historical data as an estimate for the next 5 years for each of the critical and non-critical management functions with a projected source of the funding. The budget should address items such as the cost per flying hour, cost of overhaul, costs associated with engine removal from operational aircraft, shipping costs, spare part budgets, engine planned time on wing (TOW), shop visit costs, repair costs, and margins required to assure appropriate funding is available for all operational scenarios. The ELMP shall include a master timeline and budget.

5.1.4.1.8.2 Maintenance management. The maintenance management aspects of the planning must consider the costs of repair versus replacement, the Time Compliant Technical Orders (TCTOs), flight safety, ordering/supply of materiel, and the overall scheduling of engines throughout the fleet. The ELMP shall include the maintenance management planning.

5.1.4.1.9 Technology and technology transition plan. The application of technology at the appropriate time may positively impact engine design, operation, and capability. The contractors, laboratories, engine developers, and fielded engine community must work together to make use of new technology initiatives for military and commercial applications. Technology push and pull become important factors in the flow of technology into a new engine or a fielded engine. The ELMP shall include the process for introducing new technology into fielded engines and provisions for insertion of new technology or methodology into the analyses used to support fielded engines. The process should include improvements to fielded engines.

5.1.4.1.10 Engine tests. Engine testing will continue after an engine has been fielded for an operational weapon system. The testing may include AMT/ASMET, Aircraft Pacer (Lead-the-Fleet), development testing for CIP programs, as well as testing to establish baselines for new hardware and verify either new designs or repair procedures prior to fleet introduction. The ELMP shall include the test plan for fielded engines.

5.1.4.1.11 ICD Management. The engine/aircraft ICD shall be updated throughout the life of the system to account for all relevant engine/aircraft hardware and software modifications.

5.1.4.1.12 Diminished Manufacturing Sources. All engine components shall be periodically analyzed for their vulnerability to diminishing manufacturing sources and obsolescence. Vulnerability assessments shall consider potential loss of manufacturers of items or suppliers of items or raw materials that may cause future material shortages that endanger propulsion system production or post-production support capability. If vulnerable parts are identified, a Diminished Manufacturing Source/ Obsolescence Management Plan, including risk mitigation plans, shall be required. The contractor shall be required to update these vulnerability analyses periodically in accordance with the Plan.

5.2 Performance and operability. Performance and operability is one of the end products that turbine engines provide to the warfighter. Performance is a common thread that ties all other engine technologies together. Performance can be defined as: The thrust or shaft power delivered for a given fuel flow, life, weight, engine size, and cost. This must be achieved while ensuring adequate operability. Operability can be defined as consistent and reliable starting, smooth and responsive accelerations and decelerations, stable thrust at a given power setting, and freedom from stalls, flameouts, and combustion instabilities.

5.2.1 Task II: Design Characterization and Analysis.

5.2.1.1 Environmental characterization.

5.2.1.1.1 Operating envelope. Analyses of the operating envelope requirement shall be performed to determine operating ranges and limits for all propulsion components. These analyses could identify: temperature limits of the inlet, compressor, combustor, and turbines; blowout limits of the combustor and augmentor; total pressure limits of the propulsion system and subsystems; cycle limits operating within these limits; distortion limits evaluated for the aircraft maneuver envelope; stall margin requirements with specified power extraction.

5.2.1.1.2 Operating environment. The propulsion system is usually required to operate in a wide variety of environments, including: humidity, corrosive atmosphere, and icing, and perform and operate to some level during or after ingestion of birds, ice, sand, dust, liquid water, armament gas, steam, and other foreign objects. Analyses of the operating environments shall be performed to ensure performance and operability requirements are met. These analyses may develop and/or assess design solutions for these requirements, such as airfoil leading edge radii, clearances; or define performance or stability margin budgets to accommodate these requirements.

5.2.1.1.3 Environmental emissions. Analyses shall be performed to characterize and estimate the smoke, gaseous emissions, noise, and jet wakes of the propulsion system.

5.2.1.1.4 Internal environment. Analyses shall be performed to characterize the internal environment and secondary flow of the propulsion system. These analyses could be used to facilitate estimates of bearing loads, rotor windage losses, internal cooling and leakage assessments, and structural thermal analyses.

5.2.1.2 Installation characterization.

5.2.1.2.1 Inlet/engine compatibility. Analyses shall be performed to ensure compatibility between the inlet and engine. These analyses would consider inlet recovery, distortion (steady-state and time variant, including planar wave phenomena), swirl and the induced effects of propellers or rotary wings throughout the range of aircraft maneuvers and engine airflow demands.

5.2.1.2.2 Installation demands. Analyses shall be performed to ensure the propulsion system is capable of providing the range of required customer and internal bleed flows and pressures in addition to steady-state and peak power extraction levels while still meeting requirements of the specification for the required design life.

5.2.1.2.3 Exhaust system compatibility. Analyses shall be performed to ensure compatibility between the exhaust system and engine, including thrust reverser, if applicable. This shall include consideration of performance losses due to suppression and/or external drag, and stability issues due to operating line matching.

5.2.1.2.4 Vertical/Short Take Off and Landing (V/STOL) installation. Analyses shall be performed to develop the aircraft inlet gas ingestion characteristics (either hot or cold lift jets); performance and operability effects due to any direct lift or roll bleeds; and/or performance and operability impacts due to direct drive shaft engagements and disengagements. These analyses shall consider the entire V/STOL operating envelope, including in-ground effect and mode transitions.

5.2.1.2.5 Survivability. Analyses shall be performed to ensure survivability requirements are met. Survivability requirements can have a significant impact on the design of propulsion system components. These requirements may include characteristics such as noise, infrared (IR) signature, smoke, gaseous emissions, fuel streaming, vapor puffing, water vapor contrails, radar cross section, and nuclear blast.

5.2.1.3 Performance/operability.

5.2.1.3.1 Performance model development. The performance model forms the basis to conduct numerous design analyses, which includes control schedule development, deterioration assessments, installation studies, mission assessments, stability audits, risk assessments, design trade studies, test data reduction, in-flight thrust assessment, production variation assessments, etc. The basis and method of development of the performance model shall be described. The accuracy requirements for the model shall be defined. The performance model shall be updated in accordance with the performance/operability plan.

5.2.1.3.2 Requirements assessment. Analyses shall be conducted to assess compliance with propulsion and weapon system performance requirements. This would include performance and operability projections throughout the operational envelope, deterioration assessments, production variation assessments, and include consideration of installation effects. These analyses shall be updated in accordance with the performance/operability plan.

5.2.1.3.3 Risk assessment. A risk assessment shall be performed to determine the impact on performance and operability characteristics due to production variations, component retention characteristics at full life, and development shortfalls. This risk assessment should be used for identifying high payoff improvements due to development shortfalls of component characteristics. The risk assessment shall be updated in accordance with the performance/operability plan. One method of performing a risk assessment is a Monte Carlo study, with probability distributions applied to component characteristics. As knowledge of the component and engine performance increases, other types of risk assessments should be conducted to identify and optimize resources to address emerging issues.

5.2.1.3.4 Trade and sensitivity studies. Trade and sensitivity studies shall be conducted to develop and refine requirements, allocate requirements to a lower level, perform cost/benefit analysis, and support risk assessments.

5.2.1.3.5 Failure detection and accommodation. Analyses shall be performed to ensure the control system provides adequate performance, stall margin and operability when the engine experiences control reversionary modes or fault accommodations.

5.2.1.3.6 Transient simulation development. The transient performance model forms the basis to conduct numerous operability analyses. The basis and method of development of the transient model shall be described. Accuracy requirements for the transient model shall be defined. The transient model shall be updated in accordance with the performance/operability plan.

5.2.1.3.7 Control schedule development. Analyses shall be performed to develop power management and control schedules such that all specification requirements are met, including: performance (thrust), fuel consumption, control stability, start times, acceleration, deceleration, and stall recoverability.

5.2.1.3.8 Limits assessment. Analyses shall be performed to ensure limits of over-speed, over-temperature, and overpressure are not violated.

5.2.1.3.9 Stability. Analyses shall be performed to ensure specification requirements of overshoot or undershoot, and thrust fluctuations are met. Combustor and augmentor combustion stability assessments shall be performed to ensure acceptable piloting, ignition and blowout characteristics including acceptable levels of screech and rumble.

5.2.1.3.10 Stability audit. Stability audit analyses shall be performed to ensure adequate compression system stability throughout the engine operating envelope while meeting specification requirements.

5.2.2 Task III: Components and Subsystems Testing.

5.2.2.1 Component test matrix. All component, control system bench/simulator, and core engine tests associated with performance and operability shall be identified and cross-referenced to program requirements and milestones.

5.2.2.2 Component and rig test descriptions. All component and core engine tests shall be identified and described. The scope of the proposed test program shall be included in the response to the RFP and shall be included in contractually required plans, such as the PSIP Master Plan or the IMP and IMS. The plans shall consist of information such as knowledge-based rationale for selection of scope of tests; description of test articles, procedures, test conditions and test duration; and analysis directed at the establishment of cost and schedule trade-offs used to develop the program.

5.2.3 Task IV: Propulsion System Ground and Flight Testing.

5.2.3.1 Ground and simulated altitude tests.

5.2.3.1.1 Full-scale ground test matrix. All ground and flight engine tests shall be identified and cross-referenced to program requirements and milestones. Tests required for early characterization and/or development risk reduction and those required for qualification shall be delineated.

5.2.3.1.2 Performance tests. Performance tests shall be conducted to provide data to demonstrate performance requirements. Tests shall also be conducted to update and validate the engine performance model and to provide data for development risk reduction. Performance tests shall be conducted to satisfy qualification requirements.

5.2.3.1.3 Operability tests.

5.2.3.1.3.1 Transient response. Ground and simulated altitude testing shall be performed to characterize and verify the transient response characteristics of the propulsion system. The transient performance model shall be validated to the required accuracy.

5.2.3.1.3.2 Starting. Air and ground start testing shall be performed to characterize and verify limits of capability.

5.2.3.1.3.3 Stall lines. Tests shall be performed to characterize and validate the compression system components stall or stability limit lines used in the stability audit.

5.2.3.1.3.4 Augmentor tests. Test shall be performed to characterize and verify augmentor lighting times, light-off boundary, augmentor stability (i.e., screech, rumble), and presence of pressure fluctuations that might impact engine operability.

5.2.3.1.3.5 Failure detection and accommodation. Testing shall be performed to demonstrate performance and operability during and after control reversion mode changes, seeded faults, and stall recoverability events.

5.2.3.1.3.6 Limits tests. Tests shall be performed to verify modeling of limit avoidance response, including over-speed, over-temperature, and overpressure.

5.2.3.1.3.7 Alternate fuels. If necessary, testing shall be performed with alternate or emergency fuels.

5.2.3.1.4 Accelerated Mission Test/Accelerated Simulated Mission Endurance Test (AMT/ASMET). Periodic performance and operability calibrations shall be performed throughout the AMT/ASMET to characterize and verify the deterioration rates and levels of the propulsion system. Performance and operability considerations shall be given to the test performance to ensure the test adequately verifies durability requirements. These considerations could include but not be limited to items such as: test operation with an inlet distortion screen to represent aircraft installation; operation with power management schedules and bleed and power extraction levels such that hot section time at temperatures and rotor speed ranges are achieved; number of afterburner lights for augmented engines; number of mode conversions for V/STOL applications.

5.2.3.1.5 Operating environments and ingestion tests. Tests shall be conducted to characterize and verify the performance and operability requirements during and after ingestion events and during exposure to required operating environments. Operating environments may include extreme temperature, humidity, corrosive atmosphere, and icing. Ingestion requirements may include birds, ice, sand, dust, liquid water, armament gas, steam, and other foreign objects.

5.2.3.1.6 Environmental tests. Tests shall be performed to characterize and verify the environmental characteristics of jet wake, exhaust gas emissions, and propulsion system noise.

5.2.3.1.7 Survivability tests. Tests shall be performed to characterize and verify the survivability characteristics of the propulsion system.

5.2.3.1.8 Weapon system integration.

5.2.3.1.8.1 Inlet/engine compatibility. Tests shall be performed to ensure compatibility of the engine with the inlet. The tests shall provide data to develop and verify the stability audit methodology.

5.2.3.1.8.2 Shared systems. Shared systems are those subsystems that are shared with the weapon system, such as thermal management or integrated power systems. Propulsion system ground and simulated altitude testing shall be performed to demonstrate the performance and functionality of the shared systems.

5.2.3.1.8.3 Integrated flight/propulsion controls (IFPC). For systems with integrated flight and propulsion controls (IFPC), engine testing shall be performed which includes appropriate levels of flight control laws.

5.2.3.1.8.4 Exhaust system compatibility. Tests shall be performed to ensure compatibility of the engine with the exhaust system. Compatibility considerations should include nozzle area scheduling; vectoring, if applicable; cooling; and noise suppression.

5.2.3.1.8.5 V/STOL compatibility. Tests shall be performed to ensure compatibility between the engine direct lift/roll jets and airframe inlet; and compatibility between the engine and lift bleeds (both direct lift and blown flap) and direct lift drive shafts. Compatibility includes consideration of both steady-state and transient conditions, including failure effects and accommodations.

5.2.3.1.8.6 Propeller/rotor compatibility. Integration testing shall be performed to ensure compatibility of the propeller or rotor system with the engine and airframe. Compatibility includes both aerodynamic and structural considerations.

5.2.3.1.8.7 Jet blast deflectors. Testing shall be performed to demonstrate compatibility with jet blast deflectors.

5.2.3.2 Flight tests. The tasks necessary to support the flight test program shall be identified and conducted. The tasks would include but not be limited to: flight test plans, flight test instrumentation definition, in-flight thrust model development, data reduction model development, and flight clearance assessments (including stability audits). All propulsion related flight tests shall be defined, which would include but not be limited to; performance tests; weapons system integration tests [including inlet and exhaust system compatibility, shared system testing, operability testing, weapons launch and gun fire (armament gas ingestion), and environmental testing for noise and emissions]. Tests shall also be defined for multi-engine aircraft to determine handling quality impacts both at low speed (V_{mca}) and high speed due to asymmetric thrust changes, such as engine out conditions.

5.2.4 Task V: Engine Life Management.

5.2.4.1 Engine Life Management Plan. Performance and operability considerations shall be included in the ELMP.

5.2.4.2 Technical data. The data necessary for preparation of technical data and flight manuals shall be developed. The data would include but not be limited to engine performance estimates, operability limits, and special pilot procedures.

5.2.4.3 Acceptance test procedures. The acceptance test procedures that demonstrate suitable performance and operability characteristics and allow the customer to take delivery of the engine shall be identified.

5.2.4.4 Test cell calibrations. Test cells shall be calibrated to ensure consistent performance measurement. The calibration methodology shall be approved by the contractual authority. Calibrations shall be updated periodically consistent with program and test cell requirements.

5.2.4.5 Test cell data reduction. Data reduction programs or algorithms used to analyze test cell measurements shall be developed.

5.2.4.6 New engine trending. A program shall be put into place to measure and trend production engine performance and operability characteristics.

5.2.4.7 Pacer program. Performance and operability characteristics shall be measured from Pacer or Lead-the-Fleet engines to evaluate actual deterioration rates.

5.2.4.8 Overhauled engine trending. A program shall be put into place to measure and trend overhauled engine performance and operability characteristics.

5.2.4.9 Stability audit. Stability audit analyses shall be updated periodically based on Pacer program and fleet experience to incorporate actual deterioration, aircraft usage characteristics, and impacts from any redesigned hardware to ensure adequate compression system stability throughout the engine operating envelope.

5.2.4.10 Performance baseline. The performance baseline of the engine shall be actively maintained. Performance impacts from redesigned hardware shall be tracked on a cumulative basis to ensure compliance to specification performance requirements. The performance model shall be updated to incorporate any changes to the performance baseline in accordance with the performance/operability plan.

5.2.4.11 ICD management. The engine/aircraft ICD shall be updated throughout the life of the system to account for all relevant engine/aircraft hardware and software modifications.

5.3 Controls and subsystems. Propulsion controls and subsystems constitute the majority of all equipment physically located on the external surface of an engine. Controls include those components and systems used to maintain safe and reliable operation of the entire propulsion system. Controls are analog, digital (electrical), or hydromechanical and contain redundancy based on their applications. Through proper employment of control laws, they translate pilot commands into engine commands and ultimately changes in thrust. There are generally five main control loops: air management, fuel management, nozzle position, speed, and aircraft flight control inputs. These loops work in concert to optimize weapon system performance and operability while at the same time providing engine fault detection, accommodation, as well as overspeed and overtemperature protection.

Subsystems include all components and systems that convert control commands into a physical response of the engine hardware. This response is realized through hydromechanical devices such as actuators or metering valves. Most often, an electrohydraulic servo valve is the primary means of translating an electrical control command into a hydromechanical subsystem response such as a flow or pressure. Subsystems include fuel, ignition, electrical, variable geometry, thermal management, hydraulics/fueldraulics, lubrication/scavenge, mechanical (gearbox, bearings, etc), sensing, anti-ice/de-ice, tubing/brackets, and health monitoring.

5.3.1 Task II: Design Characterization and Analysis.

5.3.1.1 Requirements analysis. All controls and subsystems shall have their design requirements flowed, allocated, or derived from higher-tier (engine and system-level) requirements. Verification requirements and methods shall be identified. All controls and subsystems requirements shall be cross-checked against higher-tier requirements.

5.3.1.2 Environmental characterizations.

5.3.1.2.1 Operating envelope. Analyses of the aircraft and engine operating envelope and mission requirements shall be performed to determine the operating environment characteristics for propulsion system controls, subsystems and their associated components. Examples of these characteristics include: aircraft induced altitudes, attitudes, speeds, accelerations/decelerations, maneuver/landing loads, vibrations, acoustics, temperatures, and pressures.

5.3.1.2.2 Operating environment. Analyses of the controls and subsystems operating environment characteristics shall be performed to determine their operating environment design and verification requirements, including assessment to avoid false/erroneous control modes. Examples of these operating environment characteristics include: temperatures, pressures, flows, humidity, fungus, corrosion, explosive atmosphere, icing, vibration, acoustics, shock, electromagnetic susceptibility effects, lightning, single event effects exposure, flight idle windmilling, primary/alternate/emergency fuels, and chemical/biological agent exposure.

5.3.1.2.3 Environmental emissions. Analyses of the controls and subsystems operating environment shall be performed to identify any emissions that may affect engine/aircraft operation or the safety of ground personnel. Examples of these emissions include: electromagnetic energies, noise, smoke, acoustics, and fuel or oil vapors and overboard leakage.

5.3.1.3 Interface characterizations.

5.3.1.3.1 Inlet/engine compatibility and ingestions. Analyses shall be performed to ensure the controls and subsystems will meet specification requirements when exposed to any adverse inlet compatibility effects or ingestions. Examples of these effects include: airflow distortion, pressures, temperatures, humidity; and the ingestion of sand, dust, water, steam, ice, armament gasses, or birds.

5.3.1.3.2 Bleeds and extractions. Analyses of aircraft requirements shall be performed to ensure the controls and subsystems will provide the required levels and rates of customer bleeds and extractions throughout the operating envelope for flight and ground operations. Examples of these bleeds and extractions include: Environmental Control System (ECS), air, hydraulic, mechanical horsepower, and electrical power.

5.3.1.3.3 Physical and operational interfaces. Analyses of the controls and subsystems shall be performed to identify and characterize all internal and external physical and operational interface design concepts and requirements. Examples of these include: engine/air vehicle architectural concepts, control/diagnostic/crew-warning interfaces, functional and physical connections, starter/generator interface (torque/speed), loads, vibrations, input/output electrical/electronic signals, electrical power supplies, mechanical power take-offs, drive trains, speeds, torques, temperatures, pressures, and flows.

5.3.1.4 Hardware.

5.3.1.4.1 Design and verification requirements. Analyses of all controls and subsystems design and verification requirements shall be performed to ensure compliance with propulsion and weapon system requirements. Examples of these design and verification requirements include: Air vehicle/engine performance and interface verification requirements (notional operational missions, performance points, throttle cycles, control/diagnostic/crew-warning interfaces, weapons interfaces, sustainment, etc.). Refer to section 5.1.1 (Engine structures Task II) for additional guidance.

5.3.1.4.2 Design service life and duty cycle. Analyses of the controls and subsystems shall be performed to determine each component's ability to meet design service life requirements when operating to their design duty cycles and within their defined operating envelopes and environments. Examples of these analyses include: maneuver loading, pressure and thermal cycles, throttle cycles, and actuation cycles. Refer to section 5.1.1 (Engine structures Task II) for additional guidance.

5.3.1.4.3 Parts classification. Analyses of all controls and subsystem components, using currently-approved reference handbooks (e.g., MIL-HDBK-1783) and documentation, shall be performed to determine their criticality classification. The classifications used shall be safety critical, mission critical, durability critical, and durability non-critical. Refer to section 5.1.1 (Engine structures Task II) for additional guidance.

5.3.1.4.4 Thermal management. Analyses of all controls and subsystem components shall be performed to identify any conditions affecting overall thermal management of the engine and air vehicle. Analysis shall be an integrated analysis with the air vehicle. Results from these analyses shall be provided for use in the air vehicle/engine thermal model.

5.3.1.4.5 Obsolescence. All electronic controls and subsystems components shall be periodically analyzed for their vulnerability to obsolescence. Results of these obsolescence analyses along with risk mitigation plans shall be included in the Obsolescence Management Plan. The contractor shall be required to update these obsolescence analyses periodically in accordance with the Obsolescence Management Plan. Examples of obsolescence analyses include: potential loss of manufacturers of items or suppliers of items or raw materials that may cause future material shortages that endanger propulsion system development, production, or post-production support capability.

5.3.1.4.6 De-rating/up-rating. Analyses of electronic controls and subsystem components shall be performed to identify and manage de-rating or up-rating their environmental and functional performance requirements. A de-rating/up-rating methodology shall be established and documented.

5.3.1.4.7 Materials. Analyses of all controls and subsystem components' material structural properties shall be accomplished. Material properties shall be quantified in advance of detail design so that proper materials selection and design operating stress levels can be established. Refer to section 5.1.1 (Engine structures Task II) for additional guidance.

5.3.1.4.8 Durability. Analyses of the controls and subsystems shall be performed to determine each component's durability (strength) characteristics when operating to their design duty cycles. Examples of these analyses include: component mount mechanical and thermal loading, plumbing loads, ground handling loads, gyroscopic moments, stresses and growth. Refer to section 5.1.1 (Engine structures Task II) for additional guidance.

5.3.1.4.9 Damage tolerance. Analyses of all safety- and mission-critical controls and subsystems shall be performed to determine each component's damage tolerance characteristics when operating to their design duty cycles. Examples of these analyses include: maximum operating stresses, flaw size and growth, leak before burst, inspection intervals, one bolt out, fracture screening, speeds, pressures, flows, and temperatures. Refer to section 5.1.1 (Engine structures Task II) for additional guidance.

5.3.1.4.10 Containment. Analyses of controls and subsystems with rotating parts shall be performed to determine their housings' ability to contain rotating parts in the event of failure. Examples of these analyses include: housing materials and construction and rotating part maximum transient speeds. Refer to section 5.1.1 (Engine structures Task II) for additional guidance.

5.3.1.4.11 Vibration. Analyses of controls and subsystems components shall be performed to determine their vibratory characteristics when operating to their design duty cycles. Examples of these analyses include: natural frequencies, resonant response, HCF, LCF, acoustics shock and pump pressure pulses. Refer to section 5.1.1 (Engine structures Task II) for additional guidance.

5.3.1.5 Performance.

5.3.1.5.1 Dynamic modeling. Analyses techniques using dynamic performance models shall be developed for all mechanical and electrical controls and subsystems to support their design, verification and life management activities. The basis and method of development of all mechanical and electrical controls and subsystems dynamic models shall be described. All mechanical and electrical controls and subsystems dynamic models shall support the engine performance dynamic model and be updated as necessary. Examples of the design, verification and life management activities include: trade studies, mission assessments, component design and lifing, control law development, performance analyses, test planning and results analyses, and problem investigations.

5.3.1.5.2 Failure detection and accommodation (FDA). Analyses of the controls and subsystems shall be performed to ensure safety- and flight-critical failures are identified and accommodated. Examples of these analyses include: fault injection, fault detection, fault isolation, control reversionary modes, redundancy management and their associated impacts on Level I and II flying qualities.

5.3.1.5.3 Stability and response. Analyses of the controls and subsystems shall be performed to ensure they provide required levels of stability and response in relation to commanded inputs. Examples of stability and response analyses include: overshoot/undershoot, thrust fluctuations, and phase and gain margins.

Analyses of the controls and subsystems shall be performed to determine their frequency and mode shape and prevention of resonant conditions resulting from any induced excitations. Examples of frequency and mode shape analyses include: critical natural frequencies determination and dynamic response characteristics.

5.3.1.5.4 Control laws, schedules, architecture, and power management. Analyses of controls and subsystems shall be performed to develop control laws, schedules, control architecture, and power management such that all specification requirements are met. Examples of these analyses include: performance (thrust), control (major loop) stability, start times, acceleration, deceleration, limit loops, and stall recoverability.

5.3.1.5.5 Electromagnetic effects and lightning. Analyses of controls and subsystems with electrical/electronic parts shall be performed to determine their electromagnetic susceptibility and emissions characteristics. Analyses of controls and subsystems shall be performed to determine their susceptibility to damage resulting from a lightning strike.

5.3.1.6 Software.

5.3.1.6.1 Software performance and testing requirements. All controls and subsystems performance requirements shall be analyzed to ensure adequate design, performance, and testing of all initial and subsequent flight release versions of safety-critical engine and air vehicle interface software. Examples of these analyses include: confirmation of component and system performance versus requirements, memory usage, worst-case timing analysis, and validity of special test equipment (electronic verification benches).

5.3.1.7 Assessments.

5.3.1.7.1 Abnormal operation (design margin). Analyses of all safety- and flight-critical controls and subsystem components shall be performed to meet program requirements in the presence of abnormal operating conditions and/or failure scenarios. Examples of these analyses include: design margin for over speeds, over temperatures, overpressures, explosive atmosphere, exposure to fire and blade-out.

5.3.1.7.2 Manufacturing and assembly processes. Analyses of controls and subsystem components' manufacturing and assembly processes shall be performed to identify any materials requiring special processes or handling and any assembly hazards. Mitigations for these risks shall be identified such that program requirements can be met.

5.3.1.7.3 Reliability and maintainability. Analyses of controls and subsystem components' reliability and maintainability shall be performed. Maintainability analyses shall be performed for both engine installed and uninstalled conditions. Examples of these analyses include: component Mean Flight Hours Between Failure (MFHBF) and Mean Time to Replace (MTTR).

5.3.1.7.3.1 Electrical/optical cable maintainability. Analyses of controls and subsystem electrical/optical cabling shall be performed to ensure they can be properly maintained when exposed to sea level cold day conditions and the expected maintenance environments including chemical/biological attacks. Examples of these analyses include: connector removal and replacement, and cable routing and placement.

5.3.1.7.4 Ground handling. Analyses of controls and subsystems components shall be performed to ensure they will not sustain damage when exposed to normal ground handling. Examples of these analyses include: component removal and replacement, transport loads, component mount loads, and plumbing loads.

5.3.2 Task III: Components and Subsystems Testing.

5.3.2.1 Component and rig test descriptions. All controls and subsystems development, IFR and ISR component, and rig testing (including air vehicle integration) requirements shall be defined. Test descriptions will include, at a high level, test objectives, facility requirements and capabilities, and subsystem/component descriptions.

5.3.2.1.1 Testing risk mitigation. To the maximum extent possible, controls and subsystems component and rig testing results shall be used to support the mitigation of known design risks. An assessment of known controls and subsystems design risks shall be accomplished in order to maximize the use of component and rig testing results in their mitigation. Examples of assessment activities include: evaluation of design assumptions, trade studies, technology readiness levels (TRLs), production variations and component residual life. The risk assessment shall be updated in accordance with the overall risk management plan.

5.3.2.2 Hardware and systems rig testing.

5.3.2.2.1 Subsystem performance. All engine controls and subsystem components (including air vehicle integration) shall be tested as necessary to resolve analytical uncertainty to verify performance and durability requirements are satisfied. Examples of these tests include: fuel/fuel delivery, lubrication, anti-ice, thermal management, ignition, actuation, sensing, electrical power, prognostic health management, thrust vectoring, variable geometry, and actuation.

5.3.2.2.2 Dry rig. All engine electronic controls shall optimize the use of dry rig test facilities during development for hardware/software integration and software development. The extent of dry rig facilities shall be governed by factors such as system complexity, technology maturity, and simulation fidelity. Examples of dry rig testing include: electronic verification bench, performance model validation, mission simulation/pilot in loop, fault injection, fault detection, fault accommodation, etc.

5.3.2.2.3 Wet rig. All controls and subsystems shall optimize the use of wet rig test facilities during development for hardware/software integration and software development. The extent of wet rig facilities shall be governed by factors such as system complexity, technology maturity, and simulation fidelity. Examples of wet rig tests include: controls system development, fuel system integration, iron bird validation, fault injection, fault detection, fault accommodation, and lubrication systems development.

5.3.2.2.4 Mechanical systems. All gearboxes, engine bearings, seals, and drives shall maximize the use of mechanical system rig test facilities during development. The scope of these rigs shall be governed by factors such as technical risk, design uncertainty, and technology maturity. Examples of mechanical systems rig tests include: bearing and seal design validation, and gearbox and power take-off development.

5.3.2.3 Hardware component.

5.3.2.3.1 Component development. If required for risk reduction, each controls and subsystem component shall undergo individual development testing to ensure an acceptable risk that its IFR and ISR design and performance requirements can be met. Examples of this development testing include: fuel pump pressure and flow, pump pressure pulses, actuator slew rate, sensor operation, electro-hydraulic servo valve operation, control stability/response, speeds, temperatures, amperes and voltages, and fault injection, detection, and accommodation.

5.3.2.3.2 Abnormal operation (design margin). All controls and subsystems components shall be considered for bench and/or rig testing to verify their ability to meet program requirements in the presence of abnormal operating conditions and/or failure scenarios. The scope of these tests shall be governed by factors such as design uncertainty, system model fidelity, and operational environment uncertainty. Examples of these tests include: overspeeds, overtemperatures, proof and burst pressure, design growth capability, performance margin, and up-rating/de-rating.

5.3.2.3.3 Reliability growth demonstration. Flight-critical controls and subsystem components shall be bench or rig tested to determine their abilities to meet reliability requirements. The scope of these tests shall consider design maturity, environmental uncertainty and severity, and safety criticality versus implementation costs. Examples of these tests include: reliability demonstration, reliability growth and test, analyze and fix.

5.3.2.3.4 Oil interruption and depletion. All lubrication subsystem components and those that require oil lubrication shall be bench or rig tested to verify their ability to tolerate normal interruptions of oil supply without damage or failure. All lubrication subsystem components and those that require oil lubrication shall be bench or rig tested to verify their ability for continued safe operation, for a specified duration, after an oil depletion event. Examples of these tests include: maneuver-induced interruptions, oil hiding, slugging, and overboard loss.

5.3.2.3.5 Component fit checks. All controls and subsystem components shall have their installations fit checked against specification requirements and/or ICDs. Examples of tools that may be used are: Catia® and Unigraphics® computer programs. Examples of physical checks include: engine envelope, clearances, and removal and replacement times.

5.3.2.3.6 Component qualification. Each controls and subsystem component shall undergo individual qualification tests to validate its IFR and ISR design and performance requirements are met. Components shall undergo endurance qualification testing at expected and extreme operational and environmental conditions. Examples of bench and engine testing include: fuel pump pressure and flow; pump pressure pulses; actuator slew rate; sensor operation; electro-hydraulic servo valve operation; control stability/response; speeds; temperatures; amperes and voltages; and fault injection, detection, and accommodation.

5.3.2.3.7 Vibration and dynamic response. All controls and subsystems components shall be tested to verify they do not contain any damaging resonant conditions or responses within the engine operating range. Examples of these tests include: pump pressure pulses, resonance response searches, ping tests and dwells, and HCF endurance.

5.3.2.3.8 Fire proof/fire resistance. All controls and subsystems components that carry flammable fluids shall be bench tested to verify they meet fire proof and fire resistance requirements.

5.3.2.4 Software testing. All initial and subsequent release versions of safety-critical controls and subsystems software, including any aircraft interface software, shall be completely tested at the applicable Unit, Computer Software Configuration (CSC), Computer Software Configuration Item (CSCI) and component levels. Examples of these tests include: peer reviews, module operation, integration (interaction and handshaking operations), fault injection, regression and full qualification (on both Application and Operational packages). All testing of initial and subsequent release versions of safety-critical controls and subsystems software, including any aircraft interface software, shall follow established government and industry standards and practices (e.g., RTCA DO-178).

5.3.3 Task IV: Propulsion System Ground and Flight Testing.

5.3.3.1 Ground and flight test descriptions. A cross-reference matrix of all required controls and subsystems hardware and software (including air vehicle integration) ground and flight testing shall be developed. Examples of these tests include: sea level, altitude, and accelerated mission engine testing, and air vehicle flight testing. The tests shall be cross-referenced with the specification paragraph it supports, in addition to a cross-reference identifying the program milestone for test completion.

5.3.3.2 Ground and flight test risk mitigation. To the maximum extent possible, controls and subsystems ground and flight testing results shall be used to support the mitigation of known design risks. An assessment of known controls and subsystems design risks shall be accomplished in order to maximize the use of ground and flight testing results in their mitigation. Examples of assessment activities include: evaluation of design assumptions, trade studies, TRLs, production variations and component residual life. All risk assessments shall be updated in accordance with the overall risk management plan.

5.3.3.3 Ground and flight test instrumentation. All controls and subsystems hardware and software flight test instrumentation requirements shall be defined in sufficient time to allow for proper procurement, installation, checkout, and flight certification where applicable.

5.3.4 Task V: Engine Life Management.

5.3.4.1 Engine Life Management Plan. The controls and subsystems shall be included in the ELMP.

5.3.4.2 Technical data development.

5.3.4.2.1 Flight manual. The controls and subsystems data necessary for preparation of the flight manuals shall be developed. The data would include but not be limited to engine performance estimates, operability limits, cautions and warnings, and special pilot procedures.

5.3.4.2.2 Maintenance procedures. The controls and subsystems data necessary for preparation of maintenance procedures shall be developed. The data would include but not be limited to engine controls and subsystems troubleshooting, removal, replacement, and overhaul procedures.

5.3.4.3 Production/overhaul quality.

5.3.4.3.1 Acceptance Test Procedures. Controls and subsystem component Acceptance Test Procedures (ATP) shall be developed by the contractor. The approved acceptance test procedures shall be used to evaluate the performance of all new production and overhauled components. New production part acceptance limits and overhauled component service limits shall be developed.

5.3.4.3.2 Component test bench calibrations. The controls and subsystem component test benches shall be routinely calibrated to ensure consistent performance measurement. The controls and subsystems test bench calibration methodology and limits shall be approved by the contractual authority.

5.3.4.4 Sustainment programs.

5.3.4.4.1 Component Improvement and Sustaining Engineering Programs. The controls and subsystems shall be included in all engine sustaining engineering and component improvement programs. These programs include: Reliability Centered Maintenance, Analytical Condition Inspection, and Component Improvement Program and Technology Transition Program (TTP). The level to which the engine controls and subsystems are included in these sustaining engineering and improvement programs shall be described in the ELMP.

5.3.4.4.2 ICD management. The engine/aircraft ICD shall be updated throughout the life of the system to account for all relevant engine/aircraft hardware and software modifications.

6. NOTES.
(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6.1 Intended use. This standard is intended as a foundation to establish and conduct a PSIP for all USAF propulsion systems developed to perform combat and support missions in environments unique to military weapons systems, and may be used by other agencies at their discretion. Contractual documents may contain tailored requirements for each program, based on the content herein.

6.2 Acquisition requirements. Acquisition documents should specify the following:

a. Title, number, and date of this standard.

6.3 Tailoring guidance. Under the provisions of this standard, the offeror can tailor the PSIP to ensure that the integrity and performance requirements will be met over the total environment in the most efficient manner. The degree to which the integrity requirements are to be applied to existing engine systems, subsystems, and components must be determined in tailoring to the specific weapon system.

6.3.1 Knowledge-based considerations. As mentioned in 4.2, the general goal of PSIP is to define the optimum set of time-phased tasks needed to increase the knowledge of the propulsion system to a sufficient level to exit the Engineering and Manufacturing Development phase. Over time, new advances in modeling and simulation, and new measurement techniques, may offer new ways to attain an equivalent level of knowledge of system characteristics. Such advances in techniques should be considered when tailoring PSIP.

6.3.2 Evolutionary acquisition. Evolutionary acquisition is the preferred DoD strategy for rapid acquisition of mature technology for the user. An evolutionary approach delivers capability in increments, recognizing, up front, the need for future capability improvements. The objective is to balance needs and available capability with resources, and to put capability into the hands of the user quickly. The success of the strategy depends on consistent and continuous definition of requirements, and the maturation of technologies that lead to disciplined development and production of systems that provide increasing capability towards a materiel concept. The approach to achieve evolutionary acquisition requires collaboration between the user, tester, and developer, and consists of Incremental Development as defined in DODI 5000.2, “Operation of the Defense Acquisition System”.

The impact of increasing use of the evolutionary acquisition approach on engine programs will be increasing occurrences of off-the-shelf engine applications and derivative engine programs. New centerline engine development programs will become rarer, simply because the cost and schedule of such programs are not consistent with those of the evolutionary acquisition programs. The following sections offer some thoughts on how the PSIP tasks may be tailored for these types of programs.

6.3.2.1 Commercial Off-The-Shelf (COTS) engine applications. In accordance with DODI 5000.2 guidelines, specific performance goals and exit criteria should be defined for each incremental development. These goals can be allocated to the engine level and provide a set of requirements. An existing engine will have a well known set of characteristics for its given application, but must be assessed to determine it’s suitability for the new application (done in Task II). Task II, Design Characterization and Analysis, would be extremely important for an off-the-shelf engine. The new application of an existing engine will help define the level of activity in all the remaining PSIP tasks. Off-the-shelf engines are often viewed as “free”—there should be no propulsion development cost to the program because the engine has already been certified. But even an existing engine may need additional development for use in a new application. For example, an existing engine used in an expanded flight envelope may indicate the need for altitude cell testing. Additionally, the design analysis could indicate that some of the subsystems should be retested to new limits or extremes. Changing the usage of the engine would indicate that an AMT/ASMET is in order and also may affect the Life Management approach.

6.3.2.2 Derivative engine programs. Derivative engine programs typically begin with a proven core, to which a new fan, or fan and low pressure turbine, is added. Cost and schedule associated with a derivative program is usually much less than for a new centerline engine. However, all five PSIP tasks still apply to a derivative program. Design work on the hardware common to an existing engine may not need to be done, but the engine system-level impacts associated with new hardware will need to be assessed using the same analysis/test process identified in the PSIP tasks. Also, changes in mission and/or internal operating conditions may affect the performance of common hardware. The necessary PSIP activities will need to be tailored uniquely to each specific, derivative program.

6.4 Subject term (key word) listing.

Analysis, durability, strength, stress, thermal
Containment
Controls
Creep
Damage tolerance
Design
Flight test
Fracture
Gas turbine engine
Ground test
High cycle fatigue (HCF)
Maintenance
Operability
Performance
Reliability
Robustness
Stability
Structures
Survivability
Systems engineering
Vibration

6.5 Changes from previous issue. The margins of this standard are marked with vertical lines to indicate where changes from the previous issue were made. This was done as a convenience only and the Government assumes no liability whatsoever for any inaccuracies in these notations. Bidders and contractors are cautioned to evaluate the requirements of this document based on the entire content irrespective of the marginal notations and relationship to the previous issue.

APPENDIX A

GUIDANCE FOR PSIP TASK COMPLETION CRITERIA AT SPECIFIC PROGRAM MILESTONES

A.1 SCOPE.
This section provides guidance to develop the Technical Review criteria for propulsion system development program milestones. It implements DoDI 5000.02 Enclosure 3 paragraph 7, Systems Engineering Technical Reviews. The PSIP Task I requires that Technical Review criteria be established for each PSIP task for the program milestones. This Appendix is not a mandatory part of the standard. The information contained herein is for guidance only.

A.2 RESOURCES.

A Service's acquisition system engineering staff should be consulted for coordination of PSIP-specific Technical Review criteria with air vehicle Technical Review entrance and exit criteria. Acquisition systems engineering maintains current definitions of program milestones as well as examples of air vehicle program entrance and exit criteria.

A.2.1 The USAF Systems Engineering office is AFLCMC/EZSI, aflcmc.ezi.mailbox@us.af.mil, (937) 656-9583.

A.2.2 Acronyms.

The following acronyms are used in propulsion Technical Reviews and supplement those listed in 3.1.

AIP	Aerodynamic Interface Plane
BOE	Basis of Estimate
CDR	Critical Design Review
CI	Configuration Item
FRR	Flight Readiness Review (equivalent to Initial Flight Release (IFR)
HW	Hardware
MOA	Memorandum of Agreement
OFP	Operational Flight Program
PDR	Preliminary Design Review
SFR	System Functional Review
SIL/SIM	System Integration Laboratory/Simulator
SOW	Statement of Work
SRR	System Requirement Review
SW	Software

A.2.3 Milestone definitions. Definitions specific to propulsion system development milestones and Technical Reviews are provided below for convenience:

System Requirement Review (SRR): The SRR is a multi-functional technical review to ensure all system and performance requirements derived from the Capability Development Document are defined and consistent with cost (program budget), schedule (program schedule), risk, and other system constraints. Generally this review assesses the system requirements captured in the system specification. The review ensures consistency between the system requirements and the preferred system solution and available technologies. It ensures that a balance has been struck between requirements and solution approach risk—that there as been convergence on a system solution that has acceptable risk and that system requirements satisfy customer requirements.

System Functional Review (SFR), formerly System Design Review (SDR): The SFR is a multi-disciplined technical review to ensure that the system under review can proceed into preliminary design, and that all system requirements and functional performance requirements derived from the Capability Development Document are defined and are consistent with cost (program budget), schedule (program schedule), risk, and other system constraints. Generally this review assesses the system functional requirements as captured in system specifications (functional baseline), and ensures that all required system performance is fully decomposed and defined in the functional baseline. System performance may be decomposed and traced to lower-level subsystem functionality that may define hardware and software requirements.

Preliminary Design Review (PDR): The PDR is a multi-disciplined technical review to ensure that the system under review can proceed into detailed design, and can meet the stated performance requirements within cost (program budget), schedule (program schedule), risk, and other system constraints. Generally, this review assesses the system preliminary design as captured in performance specifications for each configuration item (CI) in the system (allocated baseline), and ensures that each function in the functional baseline has been allocated to one or more system configuration items. A series of PDRs are normally held in the Engineering and Manufacturing Development Phase for new developments. A PDR is held for each CI or aggregation of CIs in the specification tree. Individual CI PDRs should ensure that a preliminary CI architecture is complete; a CI development specification is complete, or development specification approved; and that a preliminary allocated baseline is complete, or allocated baseline approved. A system PDR is held after completion of all CI and aggregate of CIs PDRs.

Critical Design Review (CDR): The CDR is a multi-disciplined technical review to ensure that the system under review can proceed into system fabrication, demonstration, and test; and can meet the stated performance requirements within cost (program budget), schedule (program schedule), risk, and other system constraints. A series of CDRs are normally held in the Engineering and Manufacturing Development Phase for new developments. A CDR is held for each CI and aggregation of CIs in the specification tree. A system CDR is held after completion of all CI or aggregation of CI CDRs. Even when the Government elects not to bring the allocated baseline under configuration control by the time of this review, an assessment of the flowdown of requirements from the functional baseline to the lowest level CI for each item in the specification tree should be included in the review. Any changes in the performing activity's draft allocated configuration documentation since the PDR are reviewed by the tasking activity and their impact on the functional baseline assessed and validated. This review assesses the system final design as captured in product specifications for each configuration item in the system (product baseline), and ensures that each product in the product baseline has been captured in the detailed design documentation. Product specifications for hardware enable the fabrication of configuration items, and may include production drawings. Product specifications for software (e.g., Software Design Documents) enable coding of a Computer Software Configuration Item captured in product specifications for each configuration item in the system (product baseline), and ensures that each product in the product baseline has been captured in the detailed design documentation. Product specifications for hardware enable the fabrication of configuration items, and may include production drawings. Product specifications for software (e.g., Software Design Documents) enable coding of a Computer Software Configuration Item.

Flight Readiness Review (FRR): The FRR is a multi-disciplined product and process assessment to ensure that the system under review can proceed into flight test with airworthiness standards met, objectives clearly stated, flight test data requirements clearly identified and an acceptable risk management plan defined and approved. This review also ensures that proper coordination has occurred between engineering and flight test and that all applicable disciplines understand and concur with the scope of effort that has been identified and how this effort will be executed to derive the data necessary to satisfy airworthiness and test and evaluation requirements. As such, this review shall include appropriate level of detail for each configuration to be evaluated within the flight test effort.

Initial Flight Release (IFR): This milestone is conducted to provide the Using Service and the contractor limited performance and durability verification of the engine for initial flight testing. The engine must meet limited performance, operability, or durability requirements to initiate flight test prior to the completion of this milestone. Historically, the expectation has been that durability has been demonstrated to 2X the expected flight test high time.

Full Flight Release (FFR): This milestone establishes the acceptability of the Propulsion System to power the aircraft throughout its full envelope. The Propulsion System is not required to meet full verification requirements for durability and reliability and is not required to be the final production configuration. Historically, the expectation has been that durability has been demonstrated to one full hot section life by this milestone.

Initial Service Release (ISR): The ISR milestone usually coincides with the start of Low Rate Initial Production. The acceptability of the engine for low-rate production release shall be predicated on satisfactory completion of the required verification activities and approval of the Procuring Activity. At this milestone the engine is expected to meet specification requirements. Historically, durability has been demonstrated to one cold section life at this milestone.

Operational Capability Release (OCR): The OCR milestone usually coincides with the start of Full Rate Production. The acceptability of the engine for full production release shall be predicated on satisfactory completion of the required verification activities and approval of the Procuring Activity.

A.3 GUIDANCE.

The guidance in tables A-I through A-IV should be considered fully in the Propulsion-specific Technical Review criteria used to facilitate PSIP Tasks. Table A-I provides guidance for the common Task I, table A-II for Engine Structures, table A-III for Performance and Operability, and table A-IV for Controls and Subsystems. This guidance serves to allocate air vehicle Technical Review criteria to that required for propulsion systems integrity, and as such may not be all-inclusive. Additional guidance for many of the verification activities may be found in JSSG-2007, Appendix A.

TABLE A-I. Common Task I Completion Criteria.

Program Milestone	A	B					C	
Acquisition Phase	Technology Development	Engineering and Manufacturing Development					Production and Deployment	Operations and Support
Reviews and Audits	**SRR**	**SFR**	**PDR**	**CDR**	**FRR(IFR)**	**FFR**	**ISR**	**OCR**
PSIP TASK	**TASK I: Common for all Propulsion functional areas**							
4.4.1.1 Requirements definition		Engine Specification should be complete; environmental, regulatory, cost and schedule constraints known.	ICD - critical interfaces defined - Mount characteristics (front and rear). - Inlet (flow path diameter, compatibility, observable characteristics, etc). - Nozzle (configuration. interface definitions, observable characteristics, etc). - Externals (power takeoff shaft/horsepower extraction characteristics, bleed air demands, definition of line replaceable units, fuel inlet connections, etc). - Thermal management system (physical and functional interface definitions) - Electronic controls (architecture and communication methods. Engine monitoring system definitions, electrical power supplies (primary and backup), cooling requirements, air-vehicle control law interactions/interfaces).	ICD - Signature agreements on interfaces to be verified during engine qualification activities.	ICD complete and signed-off - safety-critical interfaces verified.	ICD complete and signed-off - all interfaces verified.	Engine specification and ICD updated for production configuration.	ICD updated for relevant engine/aircraft hardware and software modifications.
4.4.1.2 Robustness assessment	Initial Assessment complete. Trade spaces and program impacts defined.	Assessment revised to consider evolution of final propulsion system requirements		Assessment updated to reflect knowledge gained from detailed design.	Assessment updated to reflect knowledge gained from engine test.		Assessment updated to reflect knowledge gained from flight test.	
4.4.2.1 Requirements management	Concept for requirements management defined and coordinated with airframe manufacturer.	Specific approach and tool defined. Tool populated with initial requirements.	Tool deployed and updated with latest requirements.	Tool updated with latest requirements.	Tool updated with latest requirements.	Tool updated with latest requirements.	Tool updated with latest requirements.	
4.4.2.2 Technical Reviews		Matrix defined with milestones consistent with PSIP Master Plan and IMP/IMS.	Matrix updated.	Matrix updated.	Matrix updated.	Matrix updated.		
4.4.2.3 PSIP Master Plan		Initial plan submitted.	Plan updated.	Plan updated.	Plan updated.	Plan updated.		

TABLE A-II. Engine Structures Task Completion Criteria.

Program Milestone	A	B					C	
Acquisition Phase	Technology Development	Engineering and Manufacturing Development					Production and Deployment	Operations and Support
Reviews and Audits	**SRR**	**SFR**	**PDR**	**CDR**	**FRR(IFR)**	**FFR**	**ISR**	**OCR**
PSIP TASK		**TASK II: Design Characterization and Analysis**						
5.1.1 Design characterization and analysis	Design System Defined Initial vehicle operational missions and environment defined. Development Tests Defined	Preliminary life analysis requirements defined and underway.	Design System updated. Preliminary life calculation completed.	Detailed analyses show that the structural and life requirement can be met within the flight envelope and is safe to fly.	Operating limits are updated based upon design analysis, and test data, and is safe to fly.	Operating limits or component operating ranges updated based upon design analysis, test data, or specification changes. Analysis and related testing has verified the engine is safe to fly throughout the flight test envelope. The limitations are to be placarded.	The engine should be cleared for full flight envelope operation based upon design analysis, ground or flight test data. Limitations and/or placards are established.	Engine is cleared for full operational capability throughout the flight envelope and environment.
5.1.1.1 Design duty cycle	Design duty cycle developed that defines all the Air Vehicle missions and environmental requirements are captured. Vehicle operational missions defined.	Operating environment requirements provided to component designers. Engine design duty cycle established and provided to component designers		Review design duty cycle to assure that it has the latest Air Vehicle missions and environmental requirements defined. Engine structural assessments reflect considerations of operating environment requirements.	Review design duty cycle to assure that it has the latest Air Vehicle missions and environmental requirements defined.	Review design duty cycle to assure that it has the latest Air Vehicle missions requirements defined. Analysis updated with engine test data for those environments deemed critical to safety of flight.		Mission usage survey taken periodically to assure that the engine is still operating with in its design limitations. Update design duty cycle per ELMP.
5.1.1.2 Material characterization	Preliminary material selections. Material data base requirements established.	Initial material characterization plan issued.	Material characteristics assessed based on design analysis and the potential impact of manufacturing processes changes. Component designs reflect accommodation of requirements.	Material characteristics assessed based on design analysis and the potential impact of manufacturing processes changes.			Material characterization complete.	

TABLE A-II. Engine Structures Task Completion Criteria - Continued.

Program Milestone	A	B					C	
Acquisition Phase	Technology Development	Engineering and Manufacturing Development					Production and Deployment	Operations and Support
Reviews and Audits	**SRR**	**SFR**	**PDR**	**CDR**	**FRR(IFR)**	**FFR**	**ISR**	**OCR**
PSIP TASK		**TASK II: Design Characterization and Analysis**						
5.1.1.3 Structural design system analysis, 5.1.1.3.1 Parts class, 5.1.1.3.2 Thermal analysis, 5.1.1.3.3 Strength analysis, 5.1.1.3.4 Stress analysis, 5.1.1.3.5 Durability analysis, 5.1.1.3.6 Damage tolerance analysis, 5.1.1.3.8 Probabilistic analysis, 5.1.1.3.9 Creep analysis, 5.1.1.3.10 Vibration and HCF, 5.1.1.3.11 Containment, 5.1.1.3.12 Engine life/sensitivity	All parts should be classified for criticality, i.e., durability, fracture, or safety critical and they should be assessed to life limiting criteria for mechanical and thermal loads by any limiting conditions defined within this task.	Initial screening of part designs should be conducted to determine what analysis must be done to assure that they meet the requirements of their classification initial structural design.	Preliminary analysis completed on part designs to determine the extent of the detailed analysis that must be done to assure that they meet the requirements of their classification.	Updated analysis completed on part designs to determine the extent of the detailed analysis that must be done to assure that they meet the requirements of their classification.	Analysis should be updated to provide evaluate any possible usage identified changes that would result in first flight limitations.	Analysis should be updated to evaluate any possible usage changes that would result in flight limitations.	Analysis should be finalized to assure that the engine meets all life requirements. Engine usage is to be monitored to provide basis for changes to operational hardware in field operation.	Engine usage monitored to provide basis for changes to operational hardware or upgrade programs to assure that there is no impact engine life.
5.1.1.4 Manufacturing and quality assessment	The Manufacturing and Quality System should be assessed to assure that the OEM can consistently produce specification compliant parts.	Define initial manufacturing and quality system.	Update manufacturing and quality assessment.	Implement manufacturing and quality planning.			Finalize baseline inspection capability and repairability.	Update inspection capability and repairability.
5.1.1.5 Design development tests		Initial development tests defined.	Engine structural development test completed and data provided to designers to update designs.	Development test result used to determine if CDR can be completed.	Follow on testing will be done for items identified for design updates.			

TABLE A-II. Engine Structures Task Completion Criteria - Continued.

Program Milestone	A	B					C	
Acquisition Phase	Technology Development	Engineering and Manufacturing Development					Production and Deployment	Operations and Support
Reviews and Audits	**SRR**	**SFR**	**PDR**	**CDR**	**FRR(IFR)**	**FFR**	**ISR**	**OCR**
PSIP TASK		**TASK III: Components and Subsystems Testing**						
5.1.2 Components and subsystems testing.	Components and subsystems test rationale, test planning developed, and test risk identified.	Components and subsystems tests initiated.	Componentsand subsystems tests continue. Results compared to analytical predictions. Analytical tools updated with test data.	Components and subsystems tests completed to support initiation of full-scale engine testing.	Components and subsystems tests completed to support flight tests.			All components and subsystems test completed.
5.1.2.1 Structural tests 5.1.2.1.1 Strength, 5.1.2.1.2 Vibration and HCF, 5.1.2.1.3 Durability, 5.1.2.1.4 Damage tolerance, 5.1.2.1.5 Containment, 5.1.2.1.6 Stiffness, 5.1.2.1.7 Thermal pressure surveys	Structural test plan developed and risk analysis determined to address all the disciplines in this section for components and subsystems.	Test risk analysis and tests initiated.	Components and subsystems testing continues to address all the disciplines in this section for components and subsystems to demonstrate their minimum structural lives.	Components and subsystems required testing is completed that assures structural life demonstrations can continue in component, rig, and core engine and full-scale engine tests.	Analysis updated with engine test data for those parts deemed critical to safety of flight.	Engine structural life limits established for full envelope flight testing with any required safety of flight placards.	All engine structural life completed.	
5.1.2.2 Engine life and sensitivity analysis	Engine life sensitivity analysis defined.	Initiate engine life sensitivity analysis.	Initial life analysis complete.	Analysis update to include data from component, core and system tests.	Analysis update to include data from system and engine tests.	Analysis update to include data from engine tests.	Analysis updated with engine test data for all required operating environments.	ELMP is to be updated resulting from operational hardware revealed deficiencies and planned engine upgrades to assure that there is no impact to engine life.

TABLE A-II. Engine Structures Task Completion Criteria - Continued.

Program Milestone	A	B					C	
Acquisition Phase	Technology Development	Engineering and Manufacturing Development					Production and Deployment	Operations and Support
Reviews and Audits	**SRR**	**SFR**	**PDR**	**CDR**	**FRR(IFR)**	**FFR**	**ISR**	**OCR**
PSIP TASK		**TASK IV: Propulsion System Ground and Flight Testing**						
5.1.3 Propulsion system ground and flight testing	Ground and Flight Test planning initiated.	Ground rules established for risk assessments, pre-test predictions, TRR, SRB, and post test assessments.	Ground and flight Testing Planning goals, risks, and tasks completed. Pre-test predictions established for each test.	Ground and Flight Test plans completed. Test Tracking system established. Test readiness review criteria established.	Ground testing complete that assure that the engine is ready for a safe limited first flight.	Ground and flight testing conducted to demonstrate the full system envelope. Post test assessments completed and lessons learned documented.	Ground and flight test have cleared the engine operating limits or component operating ranges for a full flight envelope capability.	
5.1.3.1 Ground engine tests 5.1.3.1.1 Thermal and pressure surveys, 5.1.3.1.2 Ground vibration strain & flutter boundary, 5.1.3.1.3 Dynamics, 5.1.3.1.4 Strength, 5.1.3.1.5 Blade-out, 5.1.3.1.6 Containment, 5.1.3.1.7 Overspeed/overtemperature, 5.1.3.1.8 Ingestion, 5.1.3.1.9 Accelerated Mission Test/Accelerated Simulated Mission Endurance Test (AMT/ASMET), 5.1.3.1.10 Damage tolerance	All ground and flight test requirement should be defined here that address the technical requirements of this section.	Ground rules and ground test should be initiated here. Test risk established for assessments, pre test predictions, TRR, SRB, and post test assessments.	Ground and flight Testing Planning goals, risks, and tasks completed Pre test predictions established for each test should be underway at this point.	Ground engine testing underway, test results confirms analytical predictions that supports the first flight should be completed.	Engine structural testing complete. AMT/ASMET supports limited flight test.	AMT/ASMET demonstrates one inspection interval or durability that is equivalent to twice the flight test program content.	Engine Pacer/Lead-the-Fleet testing initiated. AMT/ASMET demonstrates one design service life completed here to allow ISR release.	AMT/ASMET continues to demonstrate a full service live and to support the ELMP.
5.1.3.2 Weapon system integration	An ICD initiated here to assure successful weapon systems Integration.	The ICD should be used as a guide in the initial engine design process.	Weapon system Integration ground installed, taxi and flight testing planned.	Weapon system Integration testing and analysis is in process.		Weapon system Integration installed, taxi and flight testing conducted.	Weapon system Integration testing completed.	
5.1.3.3 Installed engine ground and flight test	Requirements for installed engine ground and flight test should be initiated here to insure engine airframe compatibility.			Fan Stress Survey, Nacelle Temperature Survey, Installed Engine Vibration Testing initiated here.		Weapon system installation and integration requirements verified Weapon system Integration ground installed, taxi and flight testing conducted.	Fan Stress Survey, Nacelle Temperature Survey, Installed Engine Vibration Testing completed.	

TABLE A-II. Engine Structures Task Completion Criteria - Continued.

Program Milestone	A	B					C	
Acquisition Phase	Technology Development	Engineering and Manufacturing Development					Production and Deployment	Operations and Support
Reviews and Audits	**SRR**	**SFR**	**PDR**	**CDR**	**FRR(IFR)**	**FFR**	**ISR**	**OCR**
PSIP TASK		**TASK V: Engine Life Management**						
5.1.4.1 Engine Life Management Plan, 5.1.4.1.1 Engine structural integrity, 5.1.4.1.2 Engine manufacturing and integration, 5.1.4.1.3 Prognostics systems, 5.1.4.1.4 Reliability-Centered Maintenance, 5.1.4.1.5 Analytic Condition Inspection and Pacer programs, 5.1.4.1.6 Mission usage/life analysis, 5.1.4.1.7 Component improvement and sustaining engineering programs, 5.1.4.1.8 Business management, 5.1.4.1.9 Technology and technology transition plan, 5.1.4.1.10 Engine tests, 5.1.4.1.11 ICD Management	Baseline ELMP established, metrics and controls defined.		Baseline ELMP established, metrics and controls established for monitoring the engine development progress.	ELMP continues.	ELMP matured to support limited flight test.	ELMP finalized for full flight testing.	ELMP developed to the point of supporting fielded engines.	ELMP continuously updated from operational aircraft maintenance and operation and the results of the Lead-the-Fleet program. ELMP executed.

TABLE A-III. Performance and Operability Task Completion Criteria.

Program Milestone	A	B					C	
Acquisition Phase	Technology Development	Engineering and Manufacturing Development					Production and Deployment	Operations and Support
Reviews and Audits	**SRR**	**SFR**	**PDR**	**CDR**	**FRR(IFR)**	**FFR**	**ISR**	**OCR**
PSIP TASK	**TASK II: Design Characterization and Analysis**							
5.2.1.1.1 Operating envelope	Vehicle operating altitudes and Mach numbers defined.	Analysis performed to define total pressure and temperature limits for the propulsion system and subsystems. Analysis to define specification requirements of altitude/Mach operating envelope, P2-T2 envelope, non-standard day temperature extremes. Analysis to define overall engine architecture including maximum airflow requirement, distortion limits, etc.	Analysis done to define initial allocation of boundary conditions to component designers, including gaspath temperature limits, stability limits of combustor and augmentor.	Roll up from detailed component analyses show the operating envelope requirement can be met. Component designer agreement and commitment to allocated requirements.	Operating limits or component operating ranges updated based upon design analysis, test data, or specification changes.		Operating limits or component operating ranges updated based upon design analysis, ground or flight test data, or specification changes.	
5.2.1.1.2 Operating environment	Vehicle operational concepts defined	Operating environment requirements provided to component designers. Engine performance estimates reflect consideration of operating environment requirements.	Component designs reflect accommodation of requirements. Engine performance and operability assessments reflect consideration of operating environment requirements.	Detailed design analysis of components show that operating envelope and engine performance and operability requirements can be met.	Analysis updated with engine test data for those environments deemed critical to safety of flight		Analysis updated with engine test data for all required operating environments.	

TABLE A-III. Performance and Operability Task Completion Criteria - Continued.

Reviews and Audits	SRR	SFR	PDR	CDR	FRR(IFR)	FFR	ISR	OCR
PSIP TASK	**TASK II: Design Characterization and Analysis**							
5.2.1.1.3 Environmental emissions		Engine architecture influenced by initial analysis of environmental emission requirements.	Component designs reflect accommodation of requirements. Engine performance and operability assessments reflect consideration of environmental emissions requirements.	Detailed component designs reflect accommodation of requirements. Engine performance and operability assessments reflect consideration of environmental emissions requirements.	Analysis of emission estimates updated with available engine test data.		Analysis of emission estimates updated with engine test data.	
5.2.1.1.4 Internal environment		Preliminary engine performance model has allocation for cooling and secondary flow.	Levels of secondary flow in engine performance model have been iterated and closed with component design models.	Secondary flow levels in engine performance model consistent with detailed component designs and any relevant rig test data.	Analysis updated with engine test data.		Analysis updated with engine test data.	
5.2.1.2.1 Inlet/ engine compatibility	Preliminary vehicle operating characteristics defined.	Analysis to establish limits for total pressure distortion, maneuver limits, and maximum airflow. Integration analysis done to define AIP for inlet model testing, data screening parameters for peak time-variant distortion, filter cutoff frequency for analog data recording and processing.	Analysis performed to establish airflow limits for inlet buzz, planar pulse, and swirl. Performance assessed with specification and/or measured levels of inlet recovery. Engine stability assessed with specification and/or measured levels of inlet distortion with estimated engine distortion sensitivity.	Stability analysis updated with inlet performance measured from scale model inlet tests and estimated engine sensitivities.	Stability analysis updated with final inlet model test data and measured engine distortion sensitivities.		Stability analysis updated with flight test results.	

TABLE A-III. Performance and Operability Task Completion Criteria - Continued.

Reviews and Audits	SRR	SFR	PDR	CDR	FRR(IFR)	FFR	ISR	OCR
PSIP TASK	**TASK II: Design Characterization and Analysis**							
5.2.1.2.2 Installation demands	Preliminary vehicle operational concepts defined.	Integration analysis performed to establish limits of power extraction and bleed flows and pressures. Limits of power extraction and bleed flows and pressures provided to component designers.	Initial component designs based on established bleed and power extraction requirements. Engine performance and operability assessments meets requirements and are consistent with initial component designs.	Detailed component designs provide established limits of installation demands. Engine performance and operability analysis based on detailed component designs show that requirements are met.	Analysis updated with engine test data.		Analysis updated with engine test data.	
5.2.1.2.3 Exhaust system compatibility	Preliminary vehicle operational concepts defined.	Integration analysis performed to establish interface limits, ranges, and rates for airframe supplied exhaust system components, such as pressure and temperature levels, area variations and control, and backpressure distortion limits.	Initial component analysis of pressure losses and performance parameters, such as velocity, thrust, or discharge coefficients. Engine performance analysis conducted with initial assessments of exhaust system installation effects.	Analysis updated based on detailed component assessments, and scale model aerodynamic and cooling tests if available.	Analysis updated with engine test data.		Analysis updated with engine ground and flight test data.	
5.2.1.2.4 V/STOL installation	Preliminary vehicle architecture and lift system defined.	Analyses performed to provide unique V/STOL operating environments of inlet gas ingestion and performance/operability budgets for lift or rolls bleeds and drive shaft engagements/disengagements.	Component designs reflect accommodation of requirements. Engine performance and operability assessments reflect consideration of V/STOL installation requirements.	Analysis updated with lift jet rig test data and/or transient models of shaft engagements and disengagements.	Analysis updated with engine test data.		Analysis updated with engine ground and flight test data.	

TABLE A-III. Performance and Operability Task Completion Criteria - Continued.

Reviews and Audits	SRR	SFR	PDR	CDR	FRR(IFR)	FFR	ISR	OCR
PSIP TASK	**TASK II: Design Characterization and Analysis**							
5.2.1.2.5 Survivability	Preliminary vehicle Operational concepts defined. Initial vehicle survivability requirements defined with initial allocation to the propulsion system. Configuration constraints identified to meet requirements (such as embedded propulsion systems or other hiding devices)	Survivability requirements budget allocated to subsystems and major components.	Initial component and propulsion system assessments to show that allocations can be met.	Analysis updated with detailed component design definition and airframe model tests.	Analysis updated with available engine and airframe model, or hardware, test data.	Analysis updated with available engine, airframe model, and weapon system test data.	Analysis updated with weapon system ground and flight test data.	Analysis updated with weapon system ground and flight test data.
5.2.1.3.1 Performance model development	Initial vehicle performance requirements defined including engine thrust class.	Parametric or study model used to establish overall engine architecture and initial performance at key engine and weapon system sizing points. Preliminary average engine performance defined.	Specification model developed. Goal component performance levels identified.	Status model developed based on detailed component design analysis.	Status model developed for IFR engine configuration. Status model developed for ISR engine configuration, if expected to be different than the IFR configuration.		Status model developed based on flight test results and initial production data.	Status model developed based on production data.
5.2.1.3.2 Requirements assessment	Initial vehicle performance requirements defined including engine thrust class.	Performance and operability requirements defined. Performance and operability related program tracking metrics identified and defined. Preliminary average engine performance defined.	Performance and operability metrics reported. Initial min to average performance variation defined. Deterioration allowance defined.	Performance and operability metrics reported. Production variation allocation and deterioration allowance supported by detailed component design analysis.	Performance and operability metrics reported. Production variation and deterioration rate updated with available engine test data.		Performance and operability metrics reported. Production variation and deterioration rate updated with available engine test data.	Performance and operability metrics reported. Production variation and deterioration rate updated with available engine test data.

TABLE A-III. Performance and Operability Task Completion Criteria - Continued.

Reviews and Audits	SRR	SFR	PDR	CDR	FRR(IFR)	FFR	ISR	OCR
PSIP TASK	**TASK II: Design Characterization and Analysis**							
5.2.1.3.3 Risk assessment	Major vehicle risk areas defined.	Methodology and schedule for conducting assessments defined.	Assessments performed in accordance with methodology and schedule.	Assessments performed in accordance with methodology, schedule, and emerging issues.	Assessments performed in accordance with methodology, schedule, and emerging issues.		Assessments performed in accordance with methodology, schedule, and emerging issues.	
5.2.1.3.4 Trade/ sensitivity studies	Studies conducted to define key technologies, requirements, risks, and levels of robustness	Studies conducted to define allocation of requirements to component/subsystem level, and to support knowledge-based development of PSIP Master Plan	Design analysis used to update knowledge-based assessments of requirements, risks, and PSIP Master Plan.	Design analysis used to update knowledge-based assessments of requirements, risks, and PSIP Master Plan.	Test results and design analysis used to update knowledge-based assessments of requirements, risks, and PSIP Master Plan.		Test results and design analysis used to update knowledge-based assessments of requirements, risks, and PSIP Master Plan.	
5.2.1.3.5 Failure detection and accommodation	Preliminary vehicle operating characteristics defined.	Control architecture defined. Vehicle safety and reliability requirements allocated to propulsions system. Reversionary mode requirements identified. Single/dual electrical failures defined. Risks identified with abatement plans.	Faults to be accommodated defined.	Transient analysis shows adequate FDA characteristics.	Analysis updated with engine test data.			
5.2.1.3.6 Transient simulation development	Preliminary vehicle operating characteristics defined.	Preliminary model consistent with architecture and aerothermo model. Evaluations of trades on core size with accel/decel and start times. Thrust and vectoring response rate requirements defined.	Initial transient model supplied to weapon system contractor. Assessment of thrust and vectoring response rate adequacy performed by weapon system contractor with transient model and supported by initial wind tunnel testing.	Model with detailed component aero analysis and validated control actuator response characteristics.	Model updated with engine and component test data.			
5.2.1.3.7 Control schedule development	Preliminary vehicle operating characteristics defined.	Initial engine cycle defined. Initial engine control architecture and technology levels defined.	Power management approaches defined.	Initial steady-state and transient control schedules developed.	Steady-state and transient schedules verified by engine test.			

TABLE A-III. Performance and Operability Task Completion Criteria - Continued.

Reviews and Audits	SRR	SFR	PDR	CDR	FRR(IFR)	FFR	ISR	OCR
PSIP TASK	**TASK II: Design Characterization and Analysis**							
5.2.1.3.8 Limits assessment	Preliminary vehicle operating characteristics defined.	Engine limits of overspeed, overtemperatue, and overpressure identified consistent with the maturity level of the engine cycle and control architecture definition.	Engine limits of overspeed, overtemperatue, and overpressure identified consistent with the component goals and power management approach.	Assessment (with current transient model of control system) of ability to maintain operation within specified limits. Actual values of overtemperature, overspeed, overpressure defined.	Analysis updated with engine test data.			
5.2.1.3.9 Stability	Preliminary vehicle operating characteristics defined.	Initial engine cycle defined. Initial engine component limits defined.	Analysis for overshoot/undershoot consistent with transient model maturity. Design consistent with analysis and design guidelines for lean blowout, screech and rumble.	Analysis for overshoot/undershoot consistent with transient model maturity. Analysis for lean blowout, screech, and rumble updated with test data.	Analysis updated with engine test data.			
5.2.1.3.10 Stability audit	Preliminary vehicle operating characteristics defined.	Stability audit methodology defined. Plan/timing for information exchange with airframe manufacture and audit updates defined.	Initial audits done with specification distortion levels, estimated distortion sensitivities and surge lines. Audits consistent with thermodynamic model maturity.	Audits updated with inlet model test distortion levels and component analysis. Audits consistent with thermodynamic model maturity.	Audits updated with measured sensitivities and stability limit lines. Audits consistent with thermodynamic model maturity.		Audits updated with flight test results. Audits consistent with thermodynamic model maturity.	Audits updated periodically with results from Pacer program and fleet experience.
PSIP TASK	**TASK III: Components and Subsystems Tests**							
5.2.2.1 Component test matrix	Major engine risk areas defined.	Initial engine system risk management plan defined. Required component tests defined. Plan delineates those component tests required for development risk reduction, and those required for qualification. Component Test Matrix defined.	Component Test Matrix updated.	Component Test Matrix updated.				

TABLE A-III. Performance and Operability Task Completion Criteria - Continued.

Reviews and Audits	SRR	SFR	PDR	CDR	FRR(IFR)	FFR	ISR	OCR
PSIP TASK	**TASK III: Components and Subsystems Tests**							
5.2.2.2 Component and rig test descriptions	Major engine risk areas defined.	Initial engine system risk management plan defined. Required component tests defined. Component Test Matrix defined.	Test descriptions developed.	Test descriptions updated.				
PSIP TASK	**TASK IV: Propulsion System Ground and Flight Tests**							
5.2.3.1.1 Full scale-ground test matrix	Major engine risk areas defined.	Initial engine system risk management plan defined. Plan delineates ground and flight tests required for development risk reduction, and those required for qualification.	Engine Test matrix updated.	Engine Test matrix updated.	Engine Test matrix updated.		Engine Test matrix updated.	
5.2.3.1.2 Performance tests	Major engine risk areas defined.	Initial engine system risk management plan defined. Performance tests needed for development risk reduction and those required for qualification delineated.			Sea level and altitude testing accomplished on a configuration to be flight cleared or verified. Planned development and/or risk reduction testing completed. Instrumentation adequate to accomplish objectives.	Sea level and altitude testing accomplished on a configuration to be flight cleared or verified. Planned development and/or risk reduction testing completed. Instrumentation adequate to accomplish objectives.	Sea level and altitude testing accomplished on a configuration to be flight cleared or verified. Planned development and/or risk reduction testing completed. Instrumentation adequate to accomplish objectives.	
5.2.3.1.3.1 Transient response	Major engine risk areas defined.	Initial engine system risk management plan defined. Full-scale engine transient response tests needed for development risk reduction and those required for qualification delineated.			Sea level and altitude testing accomplished on a configuration to be flight cleared or verified. Planned development and/or risk reduction testing completed. Instrumentation adequate to accomplish objectives.	Sea level and altitude testing accomplished on a configuration to be flight cleared or verified. Planned development and/or risk reduction testing completed. Instrumentation adequate to accomplish objectives.	Sea level and altitude testing accomplished on a configuration to be flight cleared or verified. Planned development and/or risk reduction testing completed. Instrumentation adequate to accomplish objectives.	

TABLE A-III. Performance and Operability Task Completion Criteria - Continued.

Reviews and Audits	SRR	SFR	PDR	CDR	FRR(IFR)	FFR	ISR	OCR
PSIP TASK	**TASK IV: Propulsion System Ground and Flight Tests**							
5.2.3.1.3.2 Starting	Major engine risk areas defined.	Initial engine system risk management plan defined. Full-scale engine ground and simulated air start tests needed for development risk reduction and those required for qualification delineated.			All appropriate (windmill, spooldown, simulated air and ground start) testing accomplished. Limitations affecting flight test program identified.		Ground start testing performed to extremes of environmental conditions (ambient temperatures). Starting envelopes or limitations updated based on flight test data.	
5.2.3.1.3.3 Stall line	Major engine risk areas defined.	Initial engine system risk management plan defined. Full-scale engine tests needed for compression system stall/stability limit development risk reduction and those required for qualification delineated.			Sea level and altitude testing accomplished on a configuration to be flight cleared or verified. Planned development and/or risk reduction testing completed. Instrumentation adequate to accomplish objectives.	Sea level and altitude testing accomplished on a configuration to be flight cleared or verified. Planned development and/or risk reduction testing completed. Instrumentation adequate to accomplish objectives.	Sea level and altitude testing accomplished on a configuration to be flight cleared or verified. Planned development and/or risk reduction testing completed. Instrumentation adequate to accomplish objectives.	
5.2.3.1.3.4 Augmentor tests	Major engine risk areas defined.	Initial engine system risk management plan defined. Full-scale engine tests needed for augmentor development risk reduction and those required for qualification delineated.			Sea level and altitude testing accomplished on a configuration to be flight cleared or verified. Planned development and/or risk reduction testing completed. Instrumentation adequate to accomplish objectives.	Sea level and altitude testing accomplished on a configuration to be flight cleared or verified. Planned development and/or risk reduction testing completed. Instrumentation adequate to accomplish objectives.	Sea level and altitude testing accomplished on a configuration to be flight cleared or verified. Planned development and/or risk reduction testing completed. Instrumentation adequate to accomplish objectives.	
5.2.3.1.3.5 Failure detection and accommodation	Major engine risk areas defined.	Initial engine system risk management plan defined. Full-scale engine tests needed for Failure Detection and Accommodation development risk reduction and those required for qualification delineated.			Sea level and altitude testing accomplished on a configuration to be flight cleared or verified. Planned development and/or risk reduction testing completed. Instrumentation adequate to accomplish objectives.	Sea level and altitude testing accomplished on a configuration to be flight cleared or verified. Planned development and/or risk reduction testing completed. Instrumentation adequate to accomplish objectives.	Sea level and altitude testing accomplished on a configuration to be flight cleared or verified. Planned development and/or risk reduction testing completed. Instrumentation adequate to accomplish objectives.	

TABLE A-III. Performance and Operability Task Completion Criteria - Continued.

Reviews and Audits	SRR	SFR	PDR	CDR	FRR(IFR)	FFR	ISR	OCR
PSIP TASK	**TASK IV: Propulsion System Ground and Flight Tests**							
5.2.3.1.3.6 Limits tests	Major engine risk areas defined.	Initial engine system risk management plan defined. Full-scale engine tests needed for limit avoidance response risk reduction and those required for qualification delineated.			Sea level and altitude testing accomplished on a configuration to be flight cleared or verified. Planned development and/or risk reduction testing completed. Instrumentation adequate to accomplish objectives.	Sea level and altitude testing accomplished on a configuration to be flight cleared or verified. Planned development and/or risk reduction testing completed. Instrumentation adequate to accomplish objectives.	Sea level and altitude testing accomplished on a configuration to be flight cleared or verified. Planned development and/or risk reduction testing completed. Instrumentation adequate to accomplish objectives.	
5.2.3.1.3.7 Alternate fuels	Major engine risk areas defined.	Initial engine system risk management plan defined. Full-scale engine tests needed for alternate fuel performance and operability risk reduction and those required for qualification delineated.			Sea level and altitude testing accomplished with appropriate fuels on a configuration to be flight cleared or verified. Planned development and/or risk reduction testing completed. Instrumentation adequate to accomplish objectives.	Sea level and altitude testing accomplished with appropriate fuels on a configuration to be flight cleared or verified. Planned development and/or risk reduction testing completed. Instrumentation adequate to accomplish objectives.	If needed, Sea level and altitude testing accomplished with all fuels intended for service use on a configuration to be flight cleared or verified. Planned development and/or risk reduction testing completed. Instrumentation adequate to accomplish objectives.	
5.2.3.1.4 Accelerated Mission Test/Accelerated Simulated Mission Endurance Test (AMT/ASMET)	Major engine risk areas defined.	Initial engine system risk management plan defined. Full-scale engine tests needed for deterioration rate risk reduction and those required for qualification delineated.			Deterioration rates determined for the life of the flight test program, typically two times (2X) the planned flight test hours.	Deterioration rates determined from the AMT/ASMET at this point, typically one hot section life.	Deterioration rates determined from the AMT/ASMET at this point, typically one cold section life.	
5.2.3.1.5 Operating environment and ingestion tests	Major engine risk areas defined.	Initial engine system risk management plan defined. Required components and subsystems tests defined.			Testing conducted for any environments or ingestion events deemed critical for conduct of the flight test program.		All operating environments and ingestion requirements to be verified by test completed.	

TABLE A-III. Performance and Operability Task Completion Criteria - Continued.

Reviews and Audits	SRR	SFR	PDR	CDR	FRR(IFR)	FFR	ISR	OCR
PSIP TASK	**TASK IV: Propulsion System Ground and Flight Tests**							
5.2.3.1.6 Environmental tests	Major engine risk areas defined.	Initial engine system risk management plan defined. Required components and subsystems tests defined.			Jet wake characterized to allow safe flight operations. Initial emission and noise measurements determined.		All environmental requirements to be verified by test complete.	
5.2.3.1.7 Survivability tests	Vehicle operational concepts defined. Initial vehicle survivability requirements defined.	Initial engine system risk management plan defined. Survivability tests needed for development risk reduction and those required for qualification delineated. Survivability requirement budget allocated to subsystems and major components. Initial configuration constraints defined to meet requirements (such as embedded propulsion systems or other hiding devices).			Sea level and altitude testing accomplished on a configuration to be flight cleared or verified. Planned development and/or risk reduction testing completed. Instrumentation adequate to accomplish objectives.	Sea level and altitude testing accomplished on a configuration to be flight cleared or verified. Planned development and/or risk reduction testing completed. Instrumentation adequate to accomplish objectives.	Sea level and altitude testing accomplished on a configuration to be flight cleared or verified. Planned development and/or risk reduction testing completed. Instrumentation adequate to accomplish objectives.	
5.2.3.1.8.1 Inlet/engine compatibility	Major airframe and engine risk areas defined. Scale model inlet test distortion patterns available from air frame manufacturer for proposal configuration.	Initial airframe and engine system risk management plan(s) defined. Full-scale engine tests needed for inlet/engine compatibility development risk reduction and those required for qualification delineated.	Airframe contractor supplies scale model inlet test distortion patterns at airframe system PDR.	Airframe contractor supplies final scale model inlet test distortion patterns at airframe system CDR.	Testing performed with classical and complex distortion screens. Testing also performed on other significant destabilizing influences, such as clearance sensitivity, control system accuracy, etc.	If needed, testing to capture any relevant configuration changes or methodology updates.	If needed, testing to capture any relevant configuration changes or methodology updates.	

TABLE A-III. Performance and Operability Task Completion Criteria - Continued.

Reviews and Audits	SRR	SFR	PDR	CDR	FRR(IFR)	FFR	ISR	OCR
PSIP TASK	**TASK IV: Propulsion System Ground and Flight Tests**							
5.2.3.1.8.2 Shared systems	Major airframe and engine risk areas defined.	Initial airframe and engine system risk management plan(s) defined. Full-scale engine tests needed for shared system development risk reduction and those required for qualification delineated.			Testing conducted to the extent possible with actual shared system hardware. Where not possible, the characteristics of the shared systems should be simulated.	If necessary, testing conducted to support knowledge gained from flight test.	If necessary, testing conducted to support knowledge gained from flight test.	
5.2.3.1.8.3 Integrated flight/propulsion controls (IFPC)	Major airframe and engine risk areas defined.	Initial airframe and engine system risk management plan(s) defined. Full-scale engine tests needed for IFPC development risk reduction and those required for qualification delineated.			Testing conducted to the extent possible with actual IFPC hardware and software. Where not possible, the characteristics of the IFPC should be simulated.	If necessary, testing conducted to support knowledge gained from flight test.	If necessary, testing conducted to support knowledge gained from flight test.	
5.2.3.1.8.4 Exhaust system compatibility	Major airframe and engine risk areas defined.	Initial airframe and engine system risk management plan(s) defined. Full-scale engine tests needed for exhaust system compatibility development risk reduction and those required for qualification delineated.			Sea level and altitude testing accomplished on a configuration to be flight cleared or verified. Planned development and/or risk reduction testing completed. Instrumentation adequate to accomplish objectives.	Sea level and altitude testing accomplished on a configuration to be flight cleared or verified. Planned development and/or risk reduction testing completed. Instrumentation adequate to accomplish objectives.	Sea level and altitude testing accomplished on a configuration to be flight cleared or verified. Planned development and/or risk reduction testing completed. Instrumentation adequate to accomplish objectives.	
5.2.3.1.8.5 V/STOL compatibility	Major airframe and engine risk areas defined.	Initial airframe and engine system risk management plan(s) defined. Full-scale engine tests needed for V/STOL compatibility development risk reduction and those required for qualification delineated.			Sea level and altitude testing accomplished on a configuration to be flight cleared or verified. Planned development and/or risk reduction testing completed. Instrumentation adequate to accomplish objectives.	Sea level and altitude testing accomplished on a configuration to be flight cleared or verified. Planned development and/or risk reduction testing completed. Instrumentation adequate to accomplish objectives.	Sea level and altitude testing accomplished on a configuration to be flight cleared or verified. Planned development and/or risk reduction testing completed. Instrumentation adequate to accomplish objectives.	

TABLE A-III. Performance and Operability Task Completion Criteria - Continued.

Reviews and Audits	SRR	SFR	PDR	CDR	FRR(IFR)	FFR	ISR	OCR
PSIP TASK	**TASK IV: Propulsion System Ground and Flight Tests**							
5.2.3.1.8.6 Propeller/rotor compatibility	Major airframe and engine risk areas defined.	Initial airframe and engine system risk management plan(s) defined. Full-scale engine tests needed for propeller/rotor compatibility development risk reduction and those required for qualification delineated.			Full-scale integration testing accomplished on a configuration to be flight cleared or verified. Planned development and/or risk reduction testing completed. Instrumentation adequate to accomplish objectives.	Full-scale integration testing accomplished on a configuration to be flight cleared or verified. Planned development and/or risk reduction testing completed. Instrumentation adequate to accomplish objectives.	Full-scale integration testing accomplished on a configuration to be flight cleared or verified. Planned development and/or risk reduction testing completed. Instrumentation adequate to accomplish objectives.	
5.2.3.1.8.7 Jet blast deflectors	Major airframe and engine risk areas defined.	Initial airframe and engine system risk management plan(s) defined. Initial plans related to jet blast deflector compatibility testing identified in PSIP Master Plan.	Planning for jet blast deflector compatibility updated. Analysis and modeling efforts consistent with PSIP Master Plan and IMP/IMS.	Planning for jet blast deflector compatibility updated. Analysis and modeling efforts consistent with PSIP Master Plan and IMP/IMS.	Planning for jet blast deflector compatibility updated. Analysis, modeling and testing efforts consistent with PSIP Master Plan and IMP/IMS.	Planning for jet blast deflector compatibility updated. Analysis, modeling and testing efforts consistent with PSIP Master Plan and IMP/IMS.	Planning for jet blast deflector compatibility updated. Analysis, modeling and testing efforts consistent with PSIP Master Plan and IMP/IMS.	
5.2.3.2 Flight tests	Initial airframe and engine system risk management plan(s) defined. Initial flight test tasks and performance/operability related flight tests identified in PSIP Master Plan.	Planning for flight test tasks and flight tests updated. Analysis and modeling efforts consistent with PSIP Master Plan and IMP/IMS.	Planning for flight test tasks and flight tests updated. Analysis and modeling efforts consistent with PSIP Master Plan and IMP/IMS.	Planning for flight test tasks and flight tests updated. Analysis and modeling efforts consistent with PSIP Master Plan and IMP/IMS.	Planning for flight test tasks and flight tests updated. Analysis, modeling and testing efforts consistent with PSIP Master Plan and IMP/IMS.	Planning for flight test tasks and flight tests updated. Analysis, modeling and testing efforts consistent with PSIP Master Plan and IMP/IMS.	Planning for flight test tasks and flight tests updated. Analysis, modeling and testing efforts consistent with PSIP Master Plan and IMP/IMS.	

TABLE A-III. Performance and Operability Task Completion Criteria - Continued.

Reviews and Audits	SRR	SFR	PDR	CDR	FRR(IFR)	FFR	ISR	OCR
PSIP TASK	**TASK V: Engine Life Management**							
5.2.4.2 Technical data					Flight manual and tech data developed for conduct of the flight test program.	Flight manual and tech data updated for engine configuration changes and to incorporate any initial flight test results.	Operational flight manual and tech data developed.	
5.2.4.3 Acceptance test procedures					Acceptance Test Procedures established for flight test engines.	If needed, update procedures from flight test experience.	Update procedures for production.	
5.2.4.4 Test cell calibrations		Plans for test cell calibration included in PSIP Master Plan and IMP/IMS.			Test cell calibration tasks completed consistent with PSIP Master Plan and IMP/IMS.	Test cell calibration tasks completed consistent with PSIP Master Plan and IMP/IMS.	Test cell calibration tasks completed consistent with PSIP Master Plan and IMP/IMS.	Test cell calibration tasks updated periodically consistent with program and test cell requirements.
5.2.4.5 Test cell data reduction		Plans for test cell data reduction tasks included in PSIP Master Plan.		Data reduction programs or algorithms consistent with performance model maturity.	Data reduction programs or algorithms consistent with performance model maturity.	Data reduction programs or algorithms consistent with performance model maturity.	Data reduction programs or algorithms consistent with performance model maturity.	
5.2.4.6 New engine trending				Initial plan in place for use on development engines.	Update trending plan.	Update trending plan.	Finalize trending plan.	
5.2.4.7 Pacer program							Use performance and operability trending plans to evaluate deterioration rates.	Use performance and operability trending plans to evaluate deterioration rates.
5.2.4.8 Overhauled engine trending							Initial trending plan established for overhauled engines.	Finalize overhauled engine trending plan.
5.2.4.10 Performance Baseline							Production performance baseline established.	Performance baseline maintained with cumulative impact of redesigned hardware.

TABLE A-IV. Controls and Subsystems Task Completion Criteria.

Program Milestone	A	B					C	
Acquisition Phase	Technology Development	Engineering and Manufacturing Development					Production and Deployment	Operations and Support
Reviews and Audits	**SRR**	**SFR**	**PDR**	**CDR**	**FRR(IFR)**	**FFR**	**ISR**	**OCR**
PSIP TASK	**TASK II: Design Characterization and Analysis**							
5.3.1.1 Requirements analysis	Initial vehicle requirements defined. High risk issues identified and TBDs/TBRs in work.	Controls and subsystems requirements defined. Controls and subsystems related program tracking metrics identified and defined. High and moderate risk issues identified and TBDs/TBRs in work.	Controls and subsystems tracking metrics reported. High and moderate risk issues identified and TBDs/TBRs in work.	Controls and subsystems tracking metrics reported and updated with results from simulations, rig testing, trade studies and design updates. High and moderate risk items have action plans. All TBDs/TBRs resolved. Design margins for critical performance requirements are analysis quantified; test identified, planned and scheduled (HW, SW, Procedures, Facilities, and Reporting) for verification.	Controls and subsystems tracking metrics updated with results from simulations, rig testing, engine testing, trade studies and design updates. Flight test configuration of hardware and software cleared for flight.		All hardware and software meets requirements and tracking metrics requirements.	Analysis of all design documentation (Drawings, ICD, etc.) to ensure it supports producible hardware and software complete.
5.3.1.2.1 Operating envelope	Analyses of the basic air vehicle prototype and expected production air vehicle operating envelopes and missions and definition of associated propulsion system and engine system requirements completed. Analyses of the proposed Air Vehicle Prototype Functional/Physical Architecture. Supplier MOAs in work.	Analysis of engine operating envelope system requirements completed and associated engine controls and subsystems functional requirements defined. Update controls and subsystems functional requirements using results of the analysis of the Air Vehicle Prototype Architecture. Supplier MOAs/SOWs/ BOEs developed and draft procurement specifications in work.	Analysis of engine controls and subsystems operating envelope functional requirements performed and associated controls and subsystems component design requirements defined. All component suppliers agree with allocated design requirements. Air vehicle Functional/Physical Architecture defined. Analysis of initial component designs based on operating envelope requirements complete.	Analyses of the engine controls and subsystems operating envelope component design requirements updated with development test data. Analysis to verify the controls and subsystems abilities to meet operating envelope design requirements complete. Controls and subsystems component performance models updated to include operating envelope analyses results. SIL/SIM results, trade studies and design updates scheduled prior to initial HW fabrication; SW-OFP for IFR. Final Air Vehicle Functional/Physical Architecture defined.	Analyses of the controls and subsystem components' flight test configurations updated with development and engine test data. Analyses to verify controls and subsystems abilities to meet operating envelope IFR requirements completed.		Analysis of controls and subsystems performance updated with flight test, engine and rig test data. Analysis of the hardware and software with respect to the operating envelope complete and all issues resolved.	

TABLE A-IV. Controls and Subsystems Task Completion Criteria - Continued.

Program Milestone	A	B					C	
Acquisition Phase	Technology Development	Engineering and Manufacturing Development					Production and Deployment	Operations and Support
Reviews and Audits	**SRR**	**SFR**	**PDR**	**CDR**	**FRR(IFR)**	**FFR**	**ISR**	**OCR**
PSIP TASK	**TASK II: Design Characterization and Analysis**							
5.3.1.2.2 Operating environment	Analyses of the basic air vehicle operating environment and missions complete and associated engine system requirements defined. Analyses to identify engine/air vehicle architectural concepts, control/diagnostic/crew-warning interfaces, functional information flow and physical connections complete.	Analysis of engine operating environment system requirements complete and associated engine controls and subsystems functional requirements defined.	Analysis of engine controls and subsystems operating environment functional requirements performed and associated controls and subsystems component design requirements defined. All component suppliers agree with allocated design requirements. Analysis of initial component designs based on operating environment requirements complete.	Analyses of the engine controls and subsystems operating environment component design requirements updated with development test data. Analysis of the controls and subsystems to verify abilities to meet operating environment design requirements complete. Controls and subsystems component performance models updated to include operating environment analyses results. Analysis of detailed component designs based on operating environment requirements complete.	Analyses of the controls and subsystem components' flight test configurations updated with development and engine test data. Analyses of controls and subsystems abilities to meet operating environment IFR requirements complete.		Analysis of controls and subsystems performance updated with flight test, engine and rig test data. Analysis of all hardware and software with respect to the operating environment complete and all issues resolved.	
5.3.1.2.3 Environmental emissions	Analyses of the basic air vehicle environmental emissions complete and associated engine system requirements defined.	Analysis of engine environmental emissions system requirements complete and associated engine controls and subsystems functional requirements defined.	Analysis of engine controls and subsystems environmental emissions functional requirements performed and associated controls and subsystems component design requirements defined. All component suppliers agree with allocated design requirements. Analysis of initial component designs based on environmental emissions requirements complete.	Analyses of the engine controls and subsystems environmental emissions component design requirements updated with development test data. Analysis of the controls and subsystems to verify abilities to meet environmental emissions design requirements complete. Controls and subsystems component performance models updated to include environmental emissions analyses results. Analysis of detailed component designs based on environmental emissions requirements complete.	Analyses of the controls and subsystem components' flight test configurations updated with development and engine test data. Analyses of controls and subsystems abilities to meet environmental emissions IFR requirements complete.		Analysis of controls and subsystems performance updated with flight test, engine and rig test data. Analysis of all hardware and software with respect to environmental emissions complete and all issues resolved.	

TABLE A-IV. Controls and Subsystems Task Completion Criteria - Continued.

Program Milestone	A	B					C	
Acquisition Phase	Technology Development	Engineering and Manufacturing Development					Production and Deployment	Operations and Support
Reviews and Audits	**SRR**	**SFR**	**PDR**	**CDR**	**FRR(IFR)**	**FFR**	**ISR**	**OCR**
PSIP TASK	**TASK II: Design Characterization and Analysis**							
5.3.1.3.1 Inlet/engine compatibility and ingestions	Analyses of the basic air vehicle missions, inlet/engine compatibility and ingestions exposure complete and associated engine system requirements defined.	Analysis of inlet/engine compatibility and ingestion system requirements complete and associated engine controls and subsystems functional requirements defined.	Analysis of engine controls and subsystems inlet/engine compatibility and ingestion functional requirements performed and associated controls and subsystems component design requirements defined. All component suppliers agree with allocated design requirements. Analysis of initial component designs based on Inlet/Engine Compatibility and Ingestions requirements complete.	Analyses of the engine controls and subsystems inlet/engine compatibility and ingestion component design requirements updated with development test data. Analysis of the controls and subsystems complete and verifies abilities to meet inlet/engine compatibility and ingestion design requirements. Controls and subsystems component performance models updated to include inlet/engine compatibility and ingestion analyses results. Analysis of detailed component designs based on inlet/engine compatibility and ingestion requirements complete.	Analyses of the controls and subsystem components' flight test configurations updated with development and engine test data. Analyses to verify controls and subsystems abilities to meet inlet/engine compatibility and ingestion IFR requirements complete.		Analysis of controls and subsystems performance updated with flight test, engine and rig test data. Analysis of all hardware and software with respect to inlet/engine compatibility and ingestions complete and all issues resolved.	
5.3.1.3.2 Bleeds and extractions	Analyses of the basic air vehicle missions and engine bleeds and extractions complete and associated engine system requirements defined.	Analysis of engine bleeds and extractions system requirements complete and associated engine controls and subsystems functional requirements defined.	Analysis of engine controls and subsystems bleeds and extractions functional requirements performed and associated controls and subsystems component design requirements defined. All component suppliers agree with allocated design requirements. Analysis of initial component designs based on bleeds and extractions requirements complete.	Analyses of the engine controls and subsystems bleeds and extractions component design requirements updated with development test data. Analysis to verify the controls and subsystems abilities to meet bleeds and extractions design requirements complete. Controls and subsystems component performance models updated to include bleeds and extractions analyses results. Analysis of detailed component designs based on bleeds and extractions requirements.	Analyses of the controls and subsystem components' flight test configurations updated with development and engine test data. Analyses to verify controls and subsystems abilities to meet bleeds and extractions IFR requirements complete.		Analysis of controls and subsystems performance updated with flight test, engine and rig test data. Analysis of all hardware and software with respect to bleeds and extractions complete and all issues resolved.	

TABLE A-IV. Controls and Subsystems Task Completion Criteria - Continued.

Program Milestone	A	B					C	
Acquisition Phase	Technology Development	Engineering and Manufacturing Development					Production and Deployment	Operations and Support
Reviews and Audits	**SRR**	**SFR**	**PDR**	**CDR**	**FRR(IFR)**	**FFR**	**ISR**	**OCR**
PSIP TASK	**TASK II: Design Characterization and Analysis**							
5.3.1.3.3 Physical and operational interfaces	Analyses of the basic air vehicle missions and engine physical and operational interfaces and definition of associated engine system requirements complete.	Analysis of engine physical and operational interface system requirements complete and associated engine controls and subsystems functional requirements defined.	Analysis of engine controls and subsystems physical and operational interface functional requirements performed and associated controls and subsystems component design requirements defined. All component suppliers agree with allocated design requirements. Analysis of initial component designs based on physical and operational interface requirements complete.	Analyses of the engine controls and subsystems physical and operational interface component design requirements updated with development test data. Analysis to verify the controls and subsystems abilities to meet physical and operational interface design requirements complete. Controls and subsystems component performance models include physical and operational interface analyses results. Analysis of detailed component designs based on physical and operational interface requirements complete.	Analyses of the controls and subsystem components' flight test configurations updated with development and engine test data. Analyses to verify controls and subsystems abilities to meet physical and operational interface IFR requirements complete.		Analysis of controls and subsystems performance updated with flight test, engine and rig test data. Analysis of all hardware and software with respect to physical and operational interfaces complete and all issues resolved.	
5.3.1.4.1 Design and verification requirements	Analyses of the basic air vehicle missions complete and associated engine system requirements defined.	Analysis of engine system requirements complete and associated engine controls and subsystems functional requirements defined.	Analysis of engine controls and subsystems functional requirements performed and associated controls and subsystems component design and verification requirements defined. All component suppliers agree with allocated design and verification requirements.	Analyses of the engine controls and subsystems component design and verification requirements updated with development test data. Analysis to verify the controls and subsystems abilities to meet all design and verification requirements complete. Controls and subsystems component performance models updated with analyses results.	Analyses of the controls and subsystem components' flight test configurations updated with development and engine test data. Analyses to verify controls and subsystems abilities to meet IFR requirements complete.		Analysis of controls and subsystems performance updated with flight test, engine and rig test data. Analysis of all hardware and software design and verification complete and all issues resolved.	

TABLE A-IV. Controls and Subsystems Task Completion Criteria - Continued.

Program Milestone	A	B					C	
Acquisition Phase	Technology Development	Engineering and Manufacturing Development					Production and Deployment	Operations and Support
Reviews and Audits	**SRR**	**SFR**	**PDR**	**CDR**	**FRR(IFR)**	**FFR**	**ISR**	**OCR**
PSIP TASK	**TASK II: Design Characterization and Analysis**							
5.3.1.4.2 Design service life and duty cycle	Analyses of the basic air vehicle missions complete and associated engine system requirements defined.	Analysis of engine system requirements complete and associated engine controls and subsystems functional requirements defined.	Analysis of engine controls and subsystems functional requirements performed and associated controls and subsystems component design service lives and duty cycles defined. All component suppliers agree with allocated design requirements. Analysis of initial component designs based on design service life and duty cycle requirements complete.	Analyses of the engine controls and subsystems component design service life and duty cycle requirements updated with development test data. Analysis to verify the controls and subsystems abilities to meet design service life and duty cycle requirements complete. Controls and subsystems component performance models updated to include design service life and duty cycle analyses results.	Analyses of the controls and subsystem components' flight test configurations updated with development and engine test data. Analyses to verify controls and subsystems abilities to meet design life and duty cycle IFR requirements complete.		Analysis of controls and subsystems performance updated with flight test, engine and rig test data. Analysis of all hardware and software's duty cycles complete and all issues resolved.	
5.3.1.4.3 Parts classification			Analysis of all controls and subsystem components' criticality classification initiated.	Analyses of all controls and subsystem components' criticality classification complete.			Analysis of all safety critical, mission critical, durability critical, and durability non-critical parts complete	
5.3.1.4.4 Thermal management	Analyses of the basic air vehicle missions complete and associated engine system requirements defined.	Analysis of engine thermal management system requirements complete and associated engine controls and subsystems functional requirements defined.	Analysis of engine controls and subsystems functional requirements performed and associated controls and subsystems component thermal management requirements defined. All component suppliers agree with allocated design requirements. Analysis of initial component designs based on known thermal management requirements complete.	Analyses of the engine controls and subsystems component thermal management requirements updated with air vehicle and engine development test data. Analysis to verify the controls and subsystems abilities to meet thermal management requirements complete. Controls and subsystems component performance models updated to include air vehicle and engine thermal management analyses results. Air vehicle and engine thermal models updated with controls and subsystem components' thermal analyses results.	Analyses of the controls and subsystem components' flight test configurations updated with development and engine test data. Analyses to verify controls and subsystems abilities to meet air vehicle and engine thermal management IFR requirements complete.		Analysis of controls and subsystems performance updated with flight test, engine and rig test data. Analysis of all hardware and software' with respect to thermal management complete and all issues resolved.	

TABLE A-IV. Controls and Subsystems Task Completion Criteria - Continued.

Program Milestone	A	B					C	
Acquisition Phase	Technology Development	Engineering and Manufacturing Development					Production and Deployment	Operations and Support
Reviews and Audits	**SRR**	**SFR**	**PDR**	**CDR**	**FRR(IFR)**	**FFR**	**ISR**	**OCR**
PSIP TASK	**TASK II: Design Characterization and Analysis**							
5.3.1.4.5 Obsolescence			Analysis of all electronic controls and subsystem components' production facilities, capabilities, and process audits initiated. Development of the Obsolescence Management Plan initiated. All component suppliers agree with allocated obsolescence requirements. Analyses of initial component designs consider obsolescence requirements complete.	Obsolescence Management Plan finalized and updated with development test data. Status of facility and process audits provided.			Obsolescence Management Plan updated with flight test, engine and rig test data. Finalized plan approved.	
5.3.1.4.6 De-rating/ up-rating	Analyses of the basic air vehicle missions complete and associated engine system requirements defined.	Analysis of engine system requirements complete and engine controls and subsystems electronic components' operating environment requirements defined.	Analysis of engine controls and subsystems operating environment requirements performed and associated controls and subsystems component de-rating/up-rating requirements defined. All component suppliers agree with allocated de-rating/up-rating design requirements. Analysis of initial component designs based on known de-rating/up-rating requirements complete. Development of a component de-rating/up-rating methodology initiated.	Analyses of the engine controls and subsystems component de-rating/up-rating requirements updated with development test data. Analysis to verify the controls and subsystems abilities to meet de-rating/up-rating requirements complete. Controls and subsystems electronic component models updated with de-rating/up-rating analysis results. De-rating/up-rating methodology fully documented.			Analysis of controls and subsystems electronic component de-rating/up-rating methodology documentation updated with flight test, engine and rig test data. Analysis of all hardware de-rating/up-rating complete and all issues resolved.	

TABLE A-IV. Controls and Subsystems Task Completion Criteria - Continued.

Program Milestone	A	B					C	
Acquisition Phase	Technology Development	Engineering and Manufacturing Development					Production and Deployment	Operations and Support
Reviews and Audits	**SRR**	**SFR**	**PDR**	**CDR**	**FRR(IFR)**	**FFR**	**ISR**	**OCR**
PSIP TASK	**TASK II: Design Characterization and Analysis**							
5.3.1.4.7 Materials			Analyses of all controls and subsystem components' material characterizations initiated. All component suppliers agree with allocated materials design requirements. Documented plan to accomplish detailed analyses of materials with insufficient data or operational experience created.	All controls and subsystem component material selections finalized. All controls and subsystem components' material characterization analyses complete and updated with development test data.	Analyses of the controls and subsystem components' flight test configurations updated with development and engine test data. Analyses to verify controls and subsystem component materials' abilities to meet IFR requirements complete.		Analysis of controls and subsystems component materials' performance updated with flight test, engine and rig test data. Analysis of all materials complete and all issues resolved.	
5.3.1.4.8 Durability			Analysis of engine controls and subsystems components durability requirements performed. All component suppliers agree with allocated design requirements. Analysis of initial component designs based on durability requirements complete.	Analyses of the engine controls and subsystems durability requirements updated with development test data. Analysis to verify the controls and subsystems abilities to meet durability requirements complete.	Analyses of the controls and subsystem components' flight test configurations updated with development and engine test data. Analyses to verify controls and subsystem components' ability to meet IFR durability requirements complete.		Analysis to verify controls and subsystems ability to meet durability requirements updated with flight test, engine and rig test data. Analysis of all controls and subsystems with respect to durability complete and all issues resolved.	
5.3.1.4.9 Damage tolerance			Analysis of engine controls and subsystems components damage tolerance requirements performed. All component suppliers agree with allocated design requirements. Analysis of initial component designs based on damage tolerance requirements complete.	Analyses of the engine controls and subsystems damage tolerance requirements updated with development test data. Analysis of the controls and subsystems abilities to meet damage tolerance requirements complete.			Analysis to verify controls and subsystems ability to meet damage tolerance requirements updated with flight test, engine and rig test data complete. Analysis of controls and subsystems' damage tolerance complete, and all issues resolved.	

TABLE A-IV. Controls and Subsystems Task Completion Criteria - Continued.

Program Milestone	A	B					C	
Acquisition Phase	Technology Development	Engineering and Manufacturing Development					Production and Deployment	Operations and Support
Reviews and Audits	**SRR**	**SFR**	**PDR**	**CDR**	**FRR(IFR)**	**FFR**	**ISR**	**OCR**
PSIP TASK	**TASK II: Design Characterization and Analysis**							
5.3.1.4.10 Containment			Preliminary analysis of engine controls and subsystems components with rotating parts complete and definition of containment requirements initiated. All component suppliers agree with allocated design requirements. Analysis of initial component designs based on containment requirements complete.	Analyses of the engine controls and subsystems component containment requirements updated with development test data. Analysis of the controls and subsystems abilities to meet containment requirements complete.	Analyses of the controls and subsystem components' flight test configurations updated with development and engine test data. Analyses of controls and subsystem components' ability to meet containment IFR requirements complete.		Analysis of controls and subsystems containment requirements updated with flight test, engine and rig test data. Analysis of all controls and subsystems containment complete and all issues resolved.	
5.3.1.4.11 Vibration			Analysis of engine controls and subsystems components vibration requirements performed. All component suppliers agree with allocated design requirements. Analysis of initial component designs based on vibration requirements complete.	Analyses of the engine controls and subsystems vibration requirements updated with development test data. Analysis of the controls and subsystems abilities to meet vibration requirements complete.	Analyses of the controls and subsystem components' flight test configurations updated with development and engine test data. Analyses of controls and subsystem component materials' abilities to meet IFR requirements complete.		Analysis of controls and subsystems vibration requirements updated with flight test, engine and rig test data. Analysis of all controls and subsystems vibration complete and all issues resolved.	
5.3.1.5.1 Dynamic modeling			Development of controls and subsystems' dynamic models initiated. All component suppliers agree with allocated design requirements. Analyses of initial component designs consider dynamic modeling requirements.	All controls and subsystems' dynamic models complete and validated with existing development test data.	All dynamic models updated with engine test data.		All controls and subsystems' dynamic models complete and validated. Analysis of all dynamic modeling issues complete.	

TABLE A-IV. Controls and Subsystems Task Completion Criteria - Continued.

Program Milestone	A	B					C	
Acquisition Phase	Technology Development	Engineering and Manufacturing Development					Production and Deployment	Operations and Support
Reviews and Audits	**SRR**	**SFR**	**PDR**	**CDR**	**FRR(IFR)**	**FFR**	**ISR**	**OCR**
PSIP TASK	**TASK II: Design Characterization and Analysis**							
5.3.1.5.2 Failure detection and accommodation (FDA)			Analysis of safety- and flight-critical failure modes initiated. Preliminary control architecture, level of redundancy, and accommodations defined. All component suppliers agree with allocated design requirements. Analyses of initial component designs consider FDA requirements performed.	FDA requirements updated with available dynamic model and development test data. Analysis of the controls and subsystems abilities to meet FDA requirements complete. Controls and subsystems component models updated with applicable FDA analysis results.	Analyses of the controls and subsystem components' flight test configurations FDA updated with development and engine test data. Analyses of controls and subsystem components' FDA against IFR requirements complete.		Analysis of controls and subsystem components' FDA requirements updated with flight test, engine and rig test data. Analysis of all controls and subsystems FDA complete and all issues resolved.	
5.3.1.5.3 Stability and response	Analysis of the air vehicle requirements for engine response, stability and resonant conditions, for all intended missions complete.	Analysis of the engine requirements for controls and subsystems' response, stability and resonant conditions, for all intended missions complete.	Analysis of the controls and subsystem's response, stability and resonant condition requirements for all intended missions performed. All component suppliers agree with allocated response, stability and resonant condition design requirements. Analyses of initial component designs with respect to response, stability and resonant condition requirements performed.	Analyses of the controls and subsystems' response, stability and resonant condition requirements updated with development test data. Analysis to verify the controls and subsystems abilities to meet response, stability and resonant condition requirements complete. Controls and subsystems component models updated with applicable response, stability and resonant condition analysis results.	Analyses of the controls and subsystem component flight test configurations' response, stability and resonant condition updated with development and engine test data. Analyses of controls and subsystem components' response, stability and resonant conditions against IFR requirements complete.		Analysis of controls and subsystem components' response, stability and resonant condition requirements updated with flight test, engine and rig test data. Analysis of all controls and subsystems response, stability and resonant conditions complete and all issues resolved.	

TABLE A-IV. Controls and Subsystems Task Completion Criteria - Continued.

Program Milestone	A	B					C	
Acquisition Phase	Technology Development	Engineering and Manufacturing Development					Production and Deployment	Operations and Support
Reviews and Audits	**SRR**	**SFR**	**PDR**	**CDR**	**FRR(IFR)**	**FFR**	**ISR**	**OCR**
PSIP TASK	**TASK II: Design Characterization and Analysis**							
5.3.1.5.4 Control laws, schedules, architecture, and power management	Analysis of the air vehicle requirements for engine response, stability and control, for all intended missions complete.	Analysis of the engine requirements for controls and subsystems' response, and stability and control for all intended missions complete.	Analysis of the control laws and schedules, for all intended missions, is initiated. Analysis of the controls and subsystems' architecture and power management, for all intended missions, is initiated. All component suppliers agree with allocated design requirements and architecture. Analyses of initial component designs consider control laws, schedules, architecture, and power management requirements performed.	Analyses of the control's and subsystems laws, schedules, subsystems, architecture, and power management requirements updated with development test data. Analysis to verify the controls and subsystems abilities to meet laws, schedules, architecture, and power management requirements initiated. Controls and subsystems component models updated with applicable control laws, schedules, architecture, and power management analysis results.	Analyses of the controls and subsystem flight test configurations' control laws, schedules, architecture, and power management requirements updated with development and engine test data. Analyses to verify controls and subsystems laws, schedules, architecture, and power management abilities to meet IFR requirements complete. All control laws and schedules validated by dynamic modeling and engine test results.		Analysis of controls and subsystem laws, schedules, architecture, and power management requirements updated with flight test, engine and rig test data. All control laws and schedules fully validated. Analysis of all controls and subsystems laws, schedules, architecture, and power management complete and all issues resolved.	

TABLE A-IV. Controls and Subsystems Task Completion Criteria - Continued.

Program Milestone	A	B					C	
Acquisition Phase	Technology Development	Engineering and Manufacturing Development					Production and Deployment	Operations and Support
Reviews and Audits	**SRR**	**SFR**	**PDR**	**CDR**	**FRR(IFR)**	**FFR**	**ISR**	**OCR**
PSIP TASK	**TASK II: Design Characterization and Analysis**							
5.3.1.5.5 Electromagnetic effects and lightning	Analysis of the air vehicle's electromagnetic effects and lightning emission and susceptibility requirements finalized. Development of the engine's electromagnetic effects and lightning emission and susceptibility requirements initiated.	Analysis of the engine's allocated electromagnetic effects and lightning emission and susceptibility requirements finalized.	Analysis of the controls and subsystem's allocated electromagnetic effects and lightning emission and susceptibility requirements performed. All component suppliers agree with allocated electromagnetic effects and lightning emission and susceptibility design requirements. Analyses of initial component designs considering electromagnetic effects and lightning emission and susceptibility requirements performed.	Analyses of the controls and subsystems' allocated electromagnetic effects and lightning emission and susceptibility requirements updated with development test data. Analysis to verify the controls and subsystems abilities to meet allocated electromagnetic effects and lightning emission and susceptibility requirements complete. Controls and subsystems component models updated with applicable allocated electromagnetic effects and lightning emission and susceptibility analysis results.	Analyses of the controls and subsystem flight test configurations' allocated electromagnetic effects and lightning emission and susceptibility requirements updated with development and engine test data. Analysis of controls and subsystem components' allocated electromagnetic effects and lightning emissions and susceptibilities against IFR requirements complete.		Analysis of controls and subsystem components' allocated electromagnetic effects and lightning emission and susceptibility requirements updated with flight test, engine and rig test data. Analysis of all controls and subsystems electromagnetic effects and lightning emission and susceptibility complete and all issues resolved.	
5.3.1.6.1 Software performance and testing requirements			Identification of all development, IFR and ISR controls and subsystem component and rig qualification testing requirements initiated. All application and operating system software suppliers agree with initial allocated software component and rig test requirements.	All development and IFR configuration software component and rig test requirements finalized. All application and operating system software suppliers agree with finalized allocated software component and rig test requirements. Component/subsystem models and analyses updated with software test results.	All IFR configuration software component and rig testing complete. All applicable IFR configuration software modification regression testing complete. All IFR configuration software component and rig test reports accepted. Component/subsystem models and analyses updated with software development test results.	All ISR configuration software component and rig testing requirements finalized. All application and operating system software suppliers agree with finalized allocated software component and rig test requirements.	All ISR configuration software component and rig testing complete. All applicable ISR configuration software modification regression testing complete. All ISR configuration software component and rig test reports accepted. Component/subsystem models and analyses updated with software development test results.	

TABLE A-IV. Controls and Subsystems Task Completion Criteria - Continued.

Program Milestone	A	B					C	
Acquisition Phase	Technology Development	Engineering and Manufacturing Development					Production and Deployment	Operations and Support
Reviews and Audits	**SRR**	**SFR**	**PDR**	**CDR**	**FRR(IFR)**	**FFR**	**ISR**	**OCR**
PSIP TASK	**TASK II: Design Characterization and Analysis**							
5.3.1.7.1 Abnormal operation (design margin)			Analysis of safety- and flight-critical controls and subsystem component's exposure to abnormal operating conditions initiated. All controls and subsystems component suppliers agree with allocated abnormal operation (design margin) requirements. Analyses of all controls and subsystems components with respect to abnormal operation (design margin) requirements initiated.	Analyses of the engine controls and subsystems abnormal operation (design margin) requirements updated with development test data. Analysis to verify the controls and subsystems abilities to meet abnormal operation (design margin) requirements complete. Controls and subsystems component models updated with applicable abnormal operation (design margin) analysis results.	Analysis to verify all controls and subsystems abnormal operation (design margin) capabilities against IFR requirements complete.		Analysis of controls and subsystems abnormal operation (design margin) updated with flight test, engine and rig test data. Analysis of controls and subsystems abnormal operation (design margin) complete and all issues resolved.	
5.3.1.7.2 Manufacturing and assembly processes			Analysis of controls and subsystem components' special manufacturing and assembly processes initiated. All controls and subsystems component suppliers agree with allocated manufacturing and assembly processes requirements. Analyses of all controls and subsystems components consider manufacturing and assembly process requirements initiated.	Analysis of controls and subsystem component reliability and maintainability updated with development test data. Analysis to verify the controls and subsystems abilities to meet reliability and maintainability requirements initiated. Controls and subsystems component models updated with reliability and maintainability analysis results.	Analysis of all controls and subsystems reliability and maintainability for any potential flight safety impacts initiated.		Analysis of controls and subsystem components' reliability and maintainability updated. Analysis of controls and subsystems manufacturing and assembly process complete and all issues resolved.	

TABLE A-IV. Controls and Subsystems Task Completion Criteria - Continued.

Program Milestone	A	B					C	
Acquisition Phase	Technology Development	Engineering and Manufacturing Development					Production and Deployment	Operations and Support
Reviews and Audits	**SRR**	**SFR**	**PDR**	**CDR**	**FRR(IFR)**	**FFR**	**ISR**	**OCR**
PSIP TASK	**TASK II: Design Characterization and Analysis**							
5.3.1.7.3 Reliability and maintainability	Analysis of the engine's reliability and maintainability requirements initiated. Definition of the controls and subsystem components reliability and maintainability requirements initiated.	Analysis of the engine's reliability and maintainability requirements finalized. Definition of the controls and subsystem components reliability and maintainability requirements finalized.	Analysis of controls and subsystem components' reliability and maintainability initiated. All controls and subsystems component suppliers agree with allocated reliability and maintainability requirements. Analyses of all controls and subsystems components consider reliability and maintainability requirements performed. Development of the controls and subsystems reliability and maintainability plan initiated.	Analysis of controls and subsystem components' reliability and maintainability updated with development test data. Reliability and maintainability plan updated with development test data.	Analyses of the controls and subsystem components' flight test configurations reliability and maintainability updated with development and engine test data. Analyses of controls and subsystem components' reliability and maintainability against IFR requirements.		Analysis of controls and subsystem components' reliability and maintainability requirements updated with flight test, engine and rig test data. Analysis of controls and subsystems reliability and maintainability issues complete. Controls and subsystems reliability and maintainability plan finalized.	
5.3.1.7.3.1 Electrical/ optical cable maintainability		Analysis of the engine's cold day maintenance exposure requirements completed.	Analysis of controls and subsystem's electrical/optical cabling reliability and cold day maintainability requirements initiated. All controls and subsystems electrical/optical cabling suppliers agree with cold day exposure and maintainability requirements. Analysis of all controls and subsystems electrical/optical cabling consider cold day exposure and maintainability requirements performed.	Analysis of controls and subsystem electrical/optical cabling cold day exposure and maintainability requirements updated with development test data. Analysis of the controls and subsystems electrical/optical cabling abilities to meet cold day exposure and maintainability requirements complete. Applicable updates provided to controls and subsystems reliability and maintainability plan.	Analyses of the controls and subsystem electrical/optical cabling cold day exposure and maintainability requirements updated with development and engine test data. Analyses of controls and subsystem electrical/optical cabling cold day exposure and maintainability requirements against IFR requirements.		Analysis of controls and subsystem electrical/optical cabling cold day exposure and maintainability requirements updated with flight test, engine and rig test data. Analysis of controls and subsystems electrical/optical cable maintainability issues complete. Updates provided to controls and subsystems reliability and maintainability plan.	

TABLE A-IV. Controls and Subsystems Task Completion Criteria - Continued.

Program Milestone	A	B					C	
Acquisition Phase	Technology Development	Engineering and Manufacturing Development					Production and Deployment	Operations and Support
Reviews and Audits	**SRR**	**SFR**	**PDR**	**CDR**	**FRR(IFR)**	**FFR**	**ISR**	**OCR**
PSIP TASK	**TASK II: Design Characterization and Analysis**							
5.3.1.7.4 Ground handling			Analysis of controls and subsystem components' ground handling requirements initiated. All controls and subsystems component suppliers agree with allocated ground handling requirements. Analyses of all controls and subsystems components consider ground handling requirements performed.	Analysis of controls and subsystem components' ground handling requirements updated with development test data.	Analyses of the controls and subsystem components' flight test configurations ground handling requirements updated with applicable development test data. Analyses of controls and subsystem components' ground handling requirements against IFR requirements complete.		Analysis of controls and subsystem components' ground handling requirements updated with flight test, engine and rig test data. Analysis of controls and subsystems ground handling complete and all issues resolved.	

TABLE A-IV. Controls and Subsystems Task Completion Criteria - Continued.

Program Milestone	A	B					C	
Acquisition Phase	Technology Development	Engineering and Manufacturing Development					Production and Deployment	Operations and Support
Reviews and Audits	**SRR**	**SFR**	**PDR**	**CDR**	**FRR(IFR)**	**FFR**	**ISR**	**OCR**
PSIP TASK	**TASK III: Components and Subsystems Tests**							
5.3.2.1 Component and rig test descriptions		All controls and subsystems development component and rig test requirements (including air vehicle integration) identified.	All controls and subsystems development component and rig test requirements finalized. All controls and subsystems IFR and ISR component and rig test requirements identified. Areas where similarity to other tests will be used identified. All component suppliers agree with allocated component and rig test and similarity requirements.	All controls and subsystems IFR and ISR component and rig test requirements finalized. Areas where similarity to other tests will be used finalized. Component models and analyses updated with development test results.	All controls and subsystems IFR component and rig tests complete. All IFR qualification test reports accepted. Component models and analyses updated with IFR test results.		All controls and subsystems ISR component and rig tests complete. All ISR qualification test reports accepted. Component models and analyses updated with ISR test results.	
5.3.2.1.1 Testing risk mitigation			All controls and subsystems test requirements to support risk mitigation activities identified. All component suppliers agree with planned risk mitigation activities.	All controls and subsystems test activities to support risk mitigation initiated. Component models and analyses updated with available development test results.	All testing to support safety-related risk mitigation for IFR complete. Component models and analyses updated with IFR test results.		All testing to support all risk mitigation for ISR complete. Component models and analyses updated with ISR test results.	

TABLE A-IV. Controls and Subsystems Task Completion Criteria - Continued.

Program Milestone	A	B					C	
Acquisition Phase	Technology Development	Engineering and Manufacturing Development					Production and Deployment	Operations and Support
Reviews and Audits	**SRR**	**SFR**	**PDR**	**CDR**	**FRR(IFR)**	**FFR**	**ISR**	**OCR**
PSIP TASK	**TASK III: Components and Subsystems Tests**							
5.3.2.2.1 Subsystem performance		Development component and rig test requirements for all controls and subsystem components identified.	Development component and rig test requirements for all controls and subsystem components finalized. IFR and ISR component and rig test requirements for all controls and subsystem components identified. All component suppliers agree with allocated development and IFR and ISR qualification test requirements.	IFR and ISR component and rig test requirements for all controls and subsystem components finalized. Component models and analyses updated with development test results.	IFR component and rig tests for all controls and subsystem components complete. All IFR test reports accepted. Component models and analyses updated with IFR test results.		ISR component and rig tests for all controls and subsystem components complete. All ISR qualification test reports accepted. Component models and analyses updated with ISR test results.	
5.3.2.2.2 Dry rig			Dry rig test requirements for all electronic control components (including air vehicle integration) identified. All component suppliers agree with allocated dry rig test requirements.	Dry rig test requirements for all electronic control components finalized. Component models and analyses updated with dry rig test results.	All IFR dry rig testing for all electronic control components complete. All IFR qualification test reports accepted. Component models and analyses updated with IFR dry rig test results.		All ISR dry rig testing for all electronic control components complete. All ISR qualification test reports accepted. Component models and analyses updated with ISR test results.	
5.3.2.2.3 Wet rig			Wet rig test requirements for all controls and subsystem components (including air vehicle integration) identified. All component suppliers agree with allocated wet rig test requirements.	Wet rig test requirements for all controls and subsystem components finalized. Component models and analyses updated with wet rig test results.	All IFR wet rig testing for all controls and subsystem components complete. All IFR qualification test reports accepted. Component models and analyses updated with IFR wet rig test results.		All ISR wet rig tests for all controls and subsystem components complete. All ISR qualification test reports accepted. Component models and analyses updated with ISR test results.	

TABLE A-IV. Controls and Subsystems Task Completion Criteria - Continued.

Program Milestone	A	B					C	
Acquisition Phase	Technology Development	Engineering and Manufacturing Development					Production and Deployment	Operations and Support
Reviews and Audits	**SRR**	**SFR**	**PDR**	**CDR**	**FRR(IFR)**	**FFR**	**ISR**	**OCR**
PSIP TASK	**TASK III: Components and Subsystems Tests**							
5.3.2.2.4 Mechanical systems		Mechanical systems rig test requirements (including air vehicle integration) for all controls and subsystem components identified.	Mechanical system rig test requirements for all controls and subsystem components finalized. IFR and ISR mechanical system rig test requirements for all controls and subsystem components identified. All component suppliers agree with allocated mechanical system test rig requirements.	IFR and ISR mechanical system rig test requirements for all controls and subsystem components finalized. Component models and analyses updated with mechanical system rig test results.	All IFR mechanical system rig tests for all controls and subsystem components complete. All IFR qualification test reports accepted. Component models and analyses updated with IFR test results.		All ISR mechanical system rig tests for all controls and subsystem components complete. All ISR qualification test reports accepted. Component models and analyses updated with ISR test results.	
5.3.2.3.1 Component development			Component development testing requirements identified. All component suppliers agree with allocated component test requirements.	Component development testing requirements finalized. Component models and analyses updated with development test results.	IFR configuration component testing complete. All IFR qualification test reports accepted. Component models and analyses updated with development test results.		ISR configuration component testing complete. All ISR qualification test reports accepted. Component models and analyses updated with ISR test results.	
5.3.2.3.2 Abnormal operation (design margin)			All controls and subsystems abnormal operation test requirements identified. All controls and subsystems component suppliers agree with allocated abnormal operation test requirements.	All controls and subsystems abnormal operation test requirements finalized. Controls and subsystems component models updated with applicable abnormal operation test results.	All IFR configuration controls and subsystem components abnormal operation testing complete. All IFR qualification test reports accepted. Component models and analyses updated with abnormal operation test results.		All ISR configuration controls and subsystem component testing complete. All ISR qualification test reports accepted. Component models and analyses updated with ISR abnormal operation test results.	

TABLE A-IV. Controls and Subsystems Task Completion Criteria - Continued.

Program Milestone	A	B					C	
Acquisition Phase	Technology Development	Engineering and Manufacturing Development					Production and Deployment	Operations and Support
Reviews and Audits	**SRR**	**SFR**	**PDR**	**CDR**	**FRR(IFR)**	**FFR**	**ISR**	**OCR**
PSIP TASK	**TASK III: Components and Subsystems Tests**							
5.3.2.3.3 Reliability growth/ demonstration			Reliability growth and demonstration test requirements identified. All controls and subsystem suppliers agree with allocated reliability growth and demonstration test requirements.	Reliability growth and demonstration test requirements finalized. Component models and analyses updated with applicable reliability growth and demonstration test results.	All IFR configuration reliability and growth component testing complete. All IFR qualification test reports accepted. Component models and analyses updated with applicable reliability growth and demonstration test results.		All controls and subsystem component reliability growth and demonstration testing complete. All reliability growth and demonstration test reports accepted. Component models and analyses updated with applicable reliability growth and demonstration test results.	
5.3.2.3.4 Oil interruption and depletion			Oil interruption and depletion test requirements identified. All subsystem suppliers agree with allocated oil interruption and depletion test requirements.	Oil interruption and depletion test requirements finalized. Component models and analyses updated with applicable oil interruption and depletion test results.	All IFR configuration subsystem component oil interruption and depletion testing complete. All IFR qualification test reports accepted. Component models and analyses updated with applicable oil interruption and depletion test results.		All ISR configuration subsystem component oil interruption and depletion testing complete. All ISR qualification test reports accepted. Component models and analyses updated with applicable oil interruption and depletion test results.	

TABLE A-IV. Controls and Subsystems Task Completion Criteria - Continued.

Program Milestone	A	B					C	
Acquisition Phase	Technology Development	Engineering and Manufacturing Development					Production and Deployment	Operations and Support
Reviews and Audits	**SRR**	**SFR**	**PDR**	**CDR**	**FRR(IFR)**	**FFR**	**ISR**	**OCR**
PSIP TASK	**TASK III: Components and Subsystems Tests**							
5.3.2.3.5 Component fit checks			All controls and subsystem component fit check requirements identified. All controls and subsystem component suppliers agree with allocated fit check requirements.	All IFR and ISR controls and subsystem component fit check requirements finalized.	All IFR configuration controls and subsystem component fit checks complete.		All ISR configuration controls and subsystem component fit checks complete.	
5.3.2.3.6 Component qualification			Identification of all IFR and ISR controls and subsystem component qualification testing requirements initiated. All controls and subsystem component suppliers involved in qualification requirement development.	All IFR configuration controls and subsystem component qualification requirements finalized. All controls and subsystem component suppliers agree with allocated IFR qualification requirements.	All IFR configuration component qualification testing complete. All IFR qualification reports accepted.	All ISR configuration controls and subsystem component qualification requirements finalized.	All ISR configuration controls and subsystem component qualification testing complete. All ISR qualification test reports accepted.	
5.3.2.3.7 Vibration and dynamic response			All controls and subsystem component vibration and dynamic response test requirements identified. All controls and subsystem suppliers agree with allocated vibration and dynamic response test requirements.	All IFR controls and subsystem component vibration and dynamic response test requirements finalized.	All IFR configuration controls and subsystem component vibration and dynamic response testing complete. All IFR qualification test reports accepted. Component models and analyses updated with applicable vibration and dynamic response test results.	All ISR configuration controls and subsystem component vibration and dynamic response requirements finalized.	All ISR controls and subsystem component vibration and dynamic response testing complete. All ISR test reports accepted. Component models and analyses updated with vibration and dynamic response test results.	

TABLE A-IV. Controls and Subsystems Task Completion Criteria - Continued.

Program Milestone	A	B					C	
Acquisition Phase	Technology Development	Engineering and Manufacturing Development					Production and Deployment	Operations and Support
Reviews and Audits	**SRR**	**SFR**	**PDR**	**CDR**	**FRR(IFR)**	**FFR**	**ISR**	**OCR**
PSIP TASK	**TASK III: Components and Subsystems Tests**							
5.3.2.3.8 Fire proof/ fire resistance			All controls and subsystem component fire proof/fire resistance test requirements identified. All controls and subsystem suppliers agree with allocated fire proof/fire resistance test requirements.	All IFR controls and subsystem component fire proof/fire resistance test requirements finalized.	All IFR configuration controls and subsystem component fire proof/fire resistance testing complete. All IFR qualification test reports accepted. Component models and analyses updated with applicable fire proof/fire resistance test results.	All ISR configuration controls and subsystem component fire proof/fire resistance requirements finalized.	All ISR controls and subsystem component fire proof/fire resistance testing complete. All ISR test reports accepted. Component models and analyses updated with fire proof/fire resistance test results.	
5.3.2.4 Software testing			Identification of all development, IFR and ISR controls and subsystem component and rig qualification testing requirements initiated. All application and operating system software suppliers agree with initial allocated software component and rig test requirements.	All development and IFR configuration software component and rig test requirements finalized. All application and operating system software suppliers agree with finalized allocated software component and rig test requirements. Component models and analyses updated with available software test results.	All IFR configuration software component and rig testing complete. All applicable IFR configuration software modification regression testing complete. All IFR configuration software component and rig test reports accepted. Component models and analyses updated with software development test results.	All ISR configuration software component and rig testing requirements finalized. All application and operating system software suppliers agree with finalized allocated software component and rig test requirements.	All ISR configuration software component and rig testing complete. All applicable ISR configuration software modification regression testing complete. All ISR configuration software component and rig test reports accepted. Component models and analyses updated with software development test results.	

TABLE A-IV. Controls and Subsystems Task Completion Criteria - Continued.

Program Milestone	A	B					C	
Acquisition Phase	Technology Development	Engineering and Manufacturing Development					Production and Deployment	Operations and Support
Reviews and Audits	**SRR**	**SFR**	**PDR**	**CDR**	**FRR(IFR)**	**FFR**	**ISR**	**OCR**
PSIP TASK	**TASK IV: Propulsion System Ground and Flight Tests**							
5.3.3.1 Ground and flight test descriptions			All controls and subsystem IFR and ISR hardware and software ground and flight test requirements preliminarily identified. All controls and subsystem hardware and software suppliers agree with allocated IFR and ISR ground and flight test requirements.	All IFR controls and subsystem hardware and software ground and flight test requirements finalized.	All IFR control and subsystems hardware and software ground tests complete. All IFR test reports accepted. All control and subsystems hardware and software placards and operational limitations identified and documented in appropriate documents. Component models and analyses updated with IFR test results.	All ISR control and subsystems hardware and software ground and flight test requirements finalized.	All ISR controls and subsystems hardware and software ground and flight tests complete. All ISR test reports accepted. Component models and analyses updated with ISR test results.	All ISR control and subsystems hardware and software flight tests complete. All OCR test reports accepted. Component models and analyses updated with OCR test results.
5.3.3.2 Ground and flight test risk mitigation		Methodology and schedule for conducting ground and flight testing risk assessments defined. Identification of moderate to high risk areas that could impact successful ground and flight testing or timely maturity of TRLs.	Methodology and schedule for conducting ground and flight testing risk assessments finalized. All component suppliers agree with risk assessment and update methodologies.	Initial ground and flight testing risk assessments complete in accordance with methodology and schedule. Ground and flight testing risk mitigation plans finalized for IFR configuration hardware.	All ground and flight testing risk assessments complete for IFR configuration hardware and software. All ground and flight test IFR safety risks mitigated to acceptable levels. All IFR risk assessment reports accepted. All component models updated with IFR risk assessment results.	Ground and flight testing risk mitigation plans finalized for ISR configuration hardware.	All ground and flight testing risk assessments complete for ISR configuration hardware and software. All ground and flight test ISR safety risks mitigated to acceptable levels. All ISR risk assessment reports accepted. All component models updated with ISR risk assessment results.	
5.3.3.3 Ground and flight test instrumentation			All ground test and preliminary flight test instrumentation requirements identified. Instrumentation vendors and installers agree with these requirements.	All ground test instrumentation requirements and planning complete and hardware installed and checked out for proper operation.	All flight test instrumentation requirements and planning complete, hardware installed, functionally verified, and cleared for flight.			

TABLE A-IV. Controls and Subsystems Task Completion Criteria - Continued.

Program Milestone	A	B					C	
Acquisition Phase	Technology Development	Engineering and Manufacturing Development					Production and Deployment	Operations and Support
Reviews and Audits	**SRR**	**SFR**	**PDR**	**CDR**	**FRR(IFR)**	**FFR**	**ISR**	**OCR**
PSIP TASK	**TASK V: Engine Life Management**							
5.3.4.1 Engine Life Management Plan	General weapon system life management requirements identified.	General weapon system life management requirements finalized. General engine level life management requirements identified.	Controls and subsystems life management requirements identified. Controls and subsystems component vendors agree with life management requirements.	Controls and subsystems life management requirements and methodologies finalized.	Portions of controls and subsystems life management requirements that affect IFR fully developed and documented.		Portions of controls and subsystems life management requirements that affect ISR fully developed and documented.	Portions of controls and subsystems life management requirements that affect OCR fully developed and documented.
5.3.4.2.1 Flight manual					Initial flight manual released for use during the flight test program.		Operational flight manual completed.	
5.3.4.2.2 Maintenance procedures					Maintenance procedures required for IFR fully developed and documented.		Maintenance procedures required for ISR fully developed and documented.	Maintenance procedures updated based on configuration changes and accumulated experience.
5.3.4.3.1 Acceptance test procedures			Controls and subsystem component new production preliminary ATP limits identified. Controls and subsystems vendors agree with new production preliminary ATP limits.	Controls and subsystem component new production ATP limits, that affect IFR, identified.	Controls and subsystem component new production ATP limits as well as service limits, that affect IFR, finalized.		All controls and subsystem component new production ATP limits as well as service limits, that affect ISR, fully developed and documented.	All controls and subsystem component ATP service limits fully developed and documented.

TABLE A-IV. Controls and Subsystems Task Completion Criteria - Continued.

Program Milestone	A	B					C	
Acquisition Phase	Technology Development	Engineering and Manufacturing Development					Production and Deployment	Operations and Support
Reviews and Audits	**SRR**	**SFR**	**PDR**	**CDR**	**FRR(IFR)**	**FFR**	**ISR**	**OCR**
PSIP TASK	**TASK V: Engine Life Management**							
5.3.4.3.2 Component test bench calibrations				All controls and subsystem component test bench calibration limits and procedures identified.	All controls and subsystem component test bench calibration limits and procedures, that affect IFR, fully developed and documented.		All controls and subsystem component test bench calibration limits and procedures, that affect ISR, fully developed and documented.	All controls and subsystem component test bench calibration limits and procedures fully developed and documented.
5.3.4.4.1 Component Improvement and Sustaining Engineering Programs				All controls and subsystem sustainment program requirements identified.			All controls and subsystem sustainment program requirements finalized.	All controls and subsystem sustainment program requirements fully developed and documented.

Custodians:
Army – AV
Navy – AS
Air Force – 11

Preparing activity:
Air Force – 11
(Project SESS-2015-032)

Review activities:
Army – AR
Air Force – 70, 71, 99

NOTE: The activities listed above were interested in this document as of the date of this document. Since organizations and responsibilities can change, you should verify the currency of the information above using the ASSIST Online database at https://assist.dla.mil.